Naval Research Reviews

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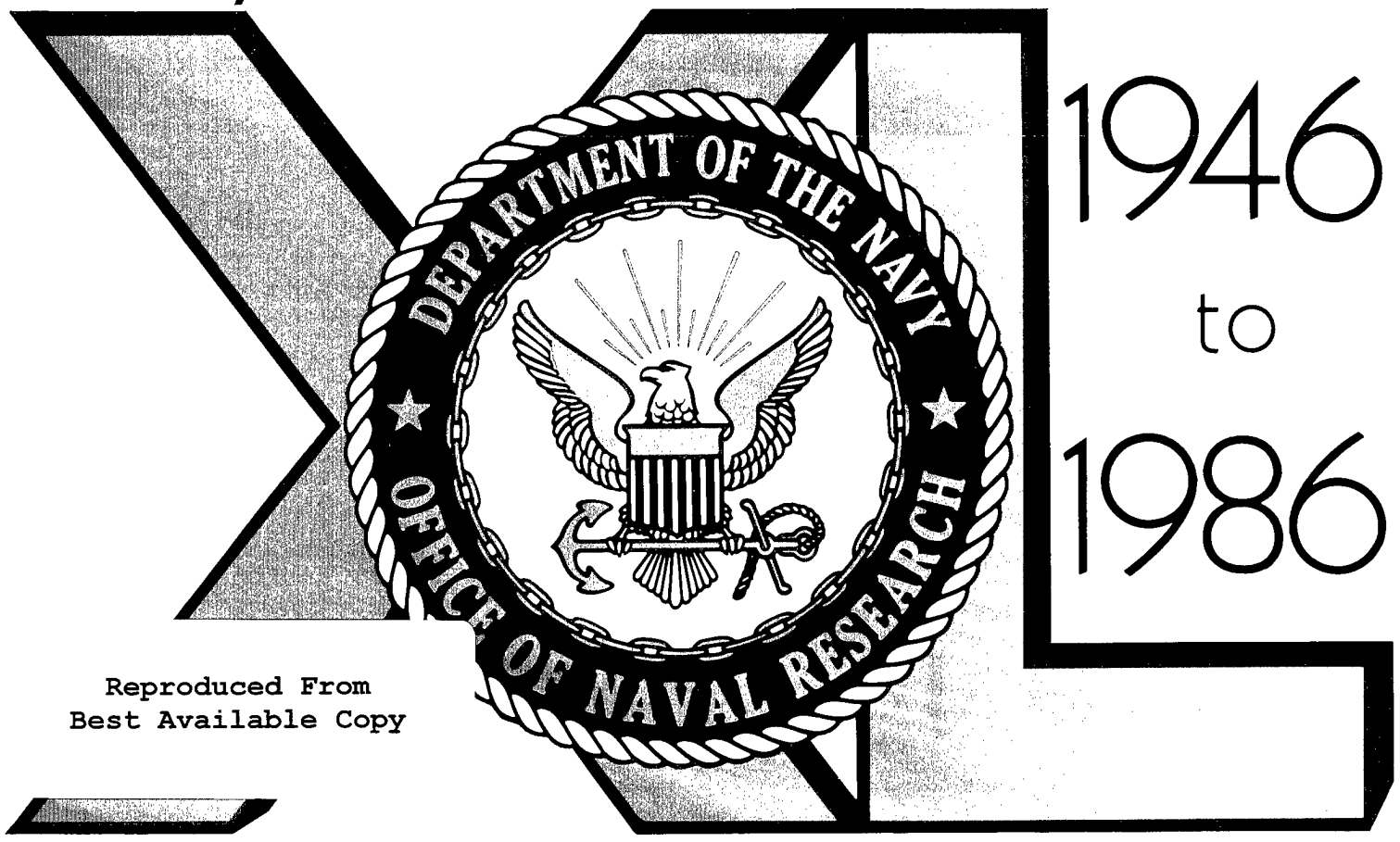
Forty Years of Excellence



1946
to
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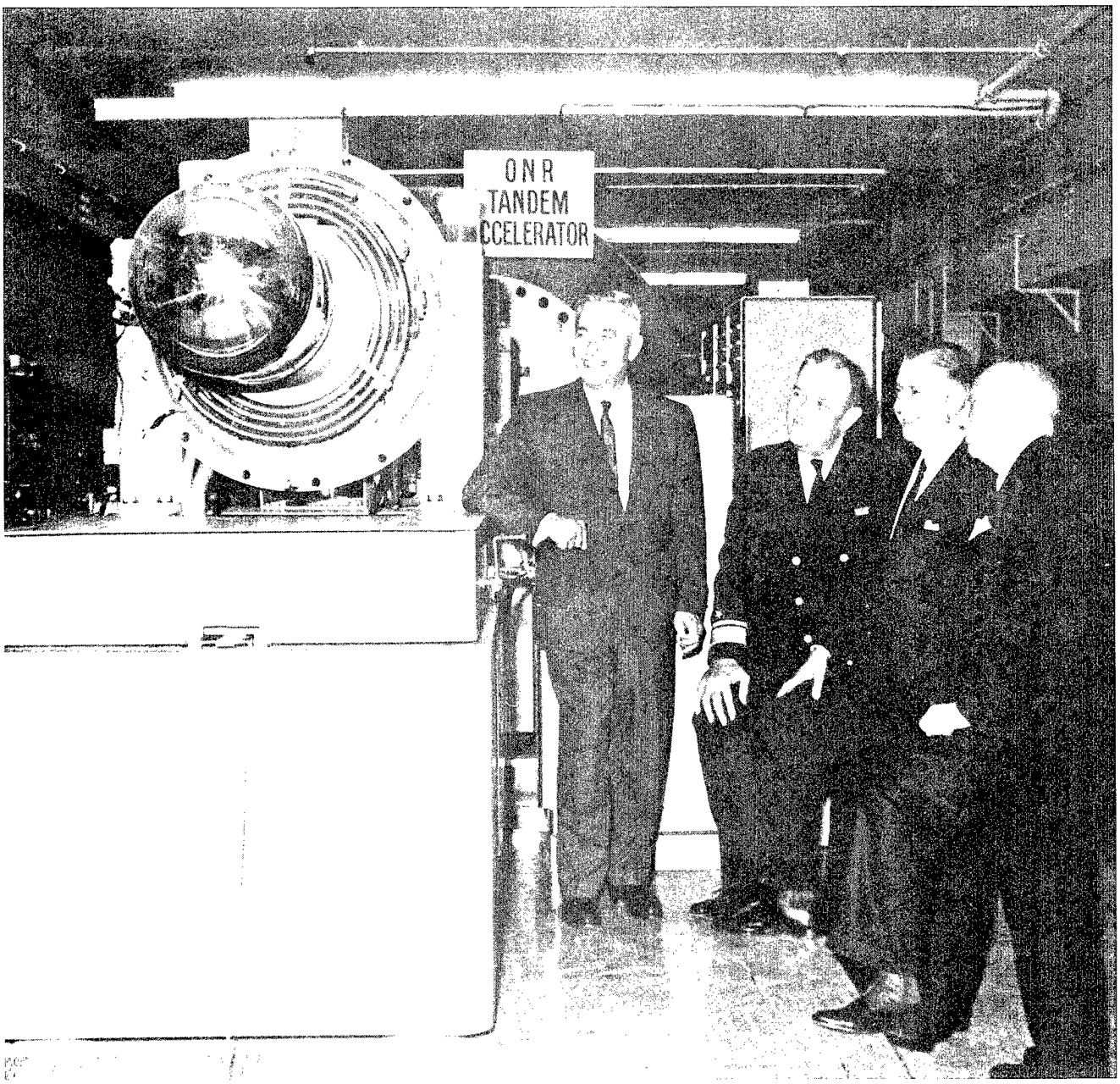
THE TANDEM ACCELERATOR



Dedication of the Office of Naval Research's Tandem Accelerator at the California Institute of Technology (CIT) on December 1, 1960. President Lee A. DuBridge of CIT points out the high voltage terminal of the helium injector to visitors Rear Admiral Rawson Bennett, USN, Chief of Naval Research, James R. Killian of the Massachusetts Institute of Technology, and Alfred P. Sloan, Jr. The Tandem Accelerator is housed in the Alfred P. Sloan Laboratory of Mathematics and Physics at CIT.

The Tandem Accelerator was the largest of a series of accelerators built by ONR for experimental and theoretical investigations of light nuclei. One of ONR's first contracts in 1946 was awarded to Professor Charles C. Lauritsen of CIT for light nuclei research. ONR's continued support of this research for 25 years led to a better understanding of the processes which occur in solar energy producing nuclear reactions and nucleosynthesis.

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About the Cover

Fortieth Anniversary Logo of the Office of Naval Research (ONR) which was designed by Dr. Logan Hargrove of ONR's Physics Division. On August 1, 1946, President Truman signed Public Law 588 which established ONR, the first permanent federal agency for funding basic research performed by the nation's civilian community.

Naval Research Reviews publishes articles about research conducted by the laboratories and contractors of the Office of Naval Research and describes important naval experimental activities. Manuscripts submitted for publication, correspondence concerning prospective articles, and changes of address, should be directed to Code OPARI, Office of Naval Research, Arlington, Va. 22217-5000. Requests for subscriptions should be directed to the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. *Naval Research Reviews* is published from appropriated funds by authority of the Office of Naval Research in accordance with Navy Publications and Printing Regulations. NAVSO P-35.

THE CHIEF OF NAVAL RESEARCH
ARLINGTON, VIRGINIA 22217

MESSAGE FROM THE CHIEF OF NAVAL RESEARCH

This year marks the 40th Anniversary of the Office of Naval Research, which is a part of my command and also the oldest scientific research contract agency in the Federal Government. The mission of ONR has always been to obtain the best scientific research for the taxpayer's dollar and to make the most effective use of this research for the Navy and the Nation.

One way ONR does this is through its contract research program, which attracts many distinguished members of the civilian scientific community to participate in a program of basic research aimed at providing the base for future technology. But, of more lasting importance, ONR developed policies and procedures forty years ago which became the organizational models for the National Science Foundation and other research agencies involving the Federal government in a comprehensive program of scientific research throughout the country. ONR continues to represent the Navy in science, coordinate naval scientific research, maintain liaison with the scientific community both in this country and abroad, and support research in nearly every major field of science. The past record of ONR makes me keenly aware of the responsibility I have in continuing its proud tradition.

Today the ONR mission is unchanged; it encourages the acquisition of fundamental knowledge needed to solve future military problems in areas such as communications, surveillance, targeting, propulsion, mobility, guidance and control, navigation, energy conversion, materials and structures, and personnel support. The Navy of the 21st Century is being planned now through the research supported by ONR.

J.B. MOONEY, JR.
RADM, USN
Chief of Naval Research

THE OFFICE OF NAVAL RESEARCH
WINDOWS TO

by Raymond D. Hagen
Office of Naval Research Historian

The role of government in research and development activities is a concept which generates both praise and controversy. In the United States, the history of the controversy is as old as our nation. From the beginning, Presidents Washington, Jefferson and Adams, in turn, tried to convince the Congress that a national university to teach the arts and sciences should have a role in building our nation's strength and reputation. The Congress never acted on those recommendations. However, Congress recognized very clearly its responsibility for authorizing a Navy. They were still close to the beginnings, when the Colonies were established and ties to their origins sustained by way of the sea. There was little difficulty in understanding that this fledgling nation needed to be defended by way of the sea, and a navy was essential to that defense.

The Navy's affinity for science is implicit in our recognition that the sea is alien to human existence and that while survival in the environment of the sea may be commonplace in limited measure, on a larger scale it is achieved through knowledge and preparation. The avenue to preparation is scientific research—a study of the conditions which must be met in order to permit the relatively fragile human body to safely invade the hostile environment of the sea. The Navy has been required to study its operational environment in very special ways in order to be prepared to conduct effective seaborne defense of our nation. An early example of basic research funded by the government was accomplished in support of naval operations on 10 February 1807 when the Congress authorized a survey of selected Atlantic coastal areas. It was a first funding of research to collect data essential for charting the coastal waters, and while the surveys concentrated on water depth, other ocean data were collected. Those surveys became the forerunner of modern Navy oceanography research which provides advanced oceanographic and meteorological forecasting for today's operating Fleet. In addition, naval oceanographic research has provided extensive benefits for commercial shipping, for marine industries and for human recreation. Our national history is rich in accounts of similar activities as science has flourished and provided welcome benefits for all aspects of growth in defense, industry, commerce and education.

The controversy has not been so much whether government should have a role but what should be the character of its role in funding basic reseach. As science and technology have become increasingly complex and costly to translate into useable benefits, private investment in the promise of future rewards has become increasingly hazardous. The burden of funding long term research and development programs must be shared or some things would never get done. The rapid advancement of science and technology between World War I and World War II was, in spite of its impressive nature, only a preview of a literal explosion of progress during and after World War II. The events we examine in this introduction to the history of the Office of Naval Research focus attention on the origins of an idea for sustaining the nation's momentum in science and technology growth that was associated with winning World War II.

Ideas come from people—not from organizations. I have been admonished by ONR plankowners and original policy-makers who were there at the beginnings, that a history of the Office of Naval Research must talk about people and their actions to have meaning. To quote one of those esteemed originals, Dr. Emmanuel R. Piore:

"The only reason it worked—this new idea—was because people were close to one another and could cut through miles of red tape to get something done by calling a friend to help. We all knew one another from working together during the war and were able to trust one another's judgment about things. A history about such things has to talk about those personal relationships and the daily exchange of information throughout the national scientific community."

That's what this montage of quotes and pictures and narrative is intended to achieve—the opening of windows into the motives, the attitudes and the actions which spawned a concept for nourishing a new growth of science and technology in the United States to serve the Navy and the Nation with advantage in a continuing quest for national security.

THE ORIGINS

Window One
The Seeds of Origin

National Security may be defined as freedom from denial of national objectives – whatever they may be, in whatever part of the world. We think of a nation enjoying national security when economic, social and military strengths support and encourage attainment of personal and individual aspirations of the citizenry as well as community objectives. Philosophers and statesmen commonly express such ideas while we all sense them intuitively. Recognizing that our individual rights and aspirations are enhanced by a sharing of strengths and responsiblities, we work together to improve the human condition. One highly visible aspect of this sense of unity is patriotism, another is dedication, another industry and still another – discovery. Historically, we are a people full of curiosity about the world around us and eager to accept the promise of creativity in our midst. We have welcomed to our shores a global-sized variety of talents and skills offering them freedom and encouragement. They have enriched our opportunities for sustaining national security and we have welcomed them into the larger creative and productive body of our nation.

The Depression of the Thirties created an immense well of despair and sense of futility about prospects for personal achievement. Industrial corporations and philanthropists providing funding for research were forced to cut back or interrupt their funding of universities or private research centers which supported the exploration of promising ideas in science. The scientist with a good idea had to fight for funds to get a project underway and keep it going. Indicative of spending on research in those difficult times are the figures displayed by the Bowman Committee in Dr. Vannevar Bush's report to the President of the United States, "Science, The Endless Frontier."[1] In 1930, universities in the United States spent a little more than $20 million on research compared with wartime spending at universities of $90 million by the Office of Scientific Research and Development (OSRD), alone. In the 1930's, most investigators had to spend an inordinate amount of their valuable time looking for money to sustain their programs. Some were compelled to abandon their hopes for a career in science to seek other kinds of gainful employment. The determined stayed on sometimes working under extremely demanding conditions, often without prospect of future rewards. From those difficult years there emerged an impressive corps of extremely capable scientists, demonstrating skills and determination that had been forged in the crucible of personal hardship so broadly associated with the depression.

Dr. Vannevar Bush

1. "Science, The Endless Frontier" was the name given a report on how to reconvert the formidable war materials production capabilities of the United States to peacetime production. It was intended to answer questions asked by President Roosevelt of Dr. Vannevar Bush in 1944. The report was not completed until after Roosevelt's death and was delivered to President Truman in July 1945. The figures quoted, above, are found on page 80, Table 1, Scientific Research Expenditures and National Income.

When it appeared inevitable that the United States would be drawn into conflict with the powerful forces of Nazi Germany and Imperial Japan, there were scientists and engineers equipped to summon knowledge and uncommon skills into the service of our nation. They were motivated by a sense of global threat and by patriotism to do what they could to strengthen our national defenses. By the Spring of 1940, a groundswell of opinion among scientists precipitated action to consider the requirements for meeting the demands of a possible wartime emergency with improved weapons and strengthened armed forces capabilities to defend the Nation. Representing a widespread expression of concern among scientists, Dr. Vannevar Bush, Vice President of Massachusetts Institute of Technology, spoke to President Roosevelt about the need to enlist the special skills of scientists to make preparations for defending ourselves in a conflict that could reach global proportions. He recommended that the President establish a civilian agency, "to coordinate, supervise and conduct scientific research on the problems underlying the development, production and use of mechanisms and devices of warfare."

On 15 June 1940, President Roosevelt responded to recommendations of the science community by establishing the National Defense Research Committee (NDRC) and appointed Dr. Vannevar Bush to be its Chairman. The Committee was not meant to replace research and development work of the military services but, rather, to supplement it with specialized research and development program activities under the supervision of selected scientists and military officials. Military officers were appointed to the Committee, including Rear Admiral Harold G. Bowen[2] who had a distinguished career in the Navy as an engineer and had pioneered the development of advanced steam propulsion systems for Navy ships and Brig. General Strong, of the Army. Civilian members included such distinguished scientists and science administrators as Dr. Karl T. Compton, President of Massachusetts Institute of Technology; Dr. James B. Conant, President of Harvard University; Dr. Frank B. Jewett, President of the National Academy of Sciences; Dr. Richard C. Tolman, California Institute of Technology; Roger Adams, University of Illinois; and Mr. Conway P. Coe, who was Commissioner of Patents.

Within a year, a powerful Office was established to galvanize the scientific and engineering resources of the nation. The Office of Scientific Research and Development (OSRD), providing the Chairman with direct access to President Roosevelt, came into being on 28 June 1941. Dr. Vannevar Bush was appointed Chairman of OSRD and became—in effect—the President's Science Advisor. The members of the Advisory Council of the OSRD included Dr. James B. Conant, serving as Chairman of the National Defense Research Committee; Dr. Jerome C. Hunsaker, Chairman of the National Advisory Committee on Aeronautics; Dr. A.N. Richards, Chairman of the Committee on Medical Research as well as several distinguished representatives from the Army and the Navy. The urgencies of the mission assigned to the Office of Scientific Research and Development helped to overcome historic resistance to government sponsorship of research as well as resistance to collaboration between scientists and uniformed military personnel. The mindset of the nation was already positively disposed toward actions which projected strength of purpose and emergency preparation to meet a threat of 'Axis' domination in Europe and Asia that could also engulf North and South America.

Dr. Jerome Hunsaker as a naval officer in World War I

2. RADM Bowen was later replaced by RADM Julius A. Furer.

Frank Knox was Secretary of the Navy in 1941, when the Office of Scientific Research and Development (OSRD) was established. He was urged by Dr. Bush and Dr. Hunsaker to make provision for effective liaison between the Navy and OSRD so that Navy requirements for readiness would be quickly communicated to the OSRD, where all decisions were being made concerning allocation of resources and priorities for building weapons. In a letter[3] to Assistant Secretary of the Navy, James Forrestal, Dr. Hunsaker recommends a research coordinator in the Office of the Secretary of the Navy. As an enclosure to the letter, Hunsaker submits the words for General Order #150, replacing General Orders #124 and #130 dating back to Thomas Edison and his association with the Naval Research Laboratory. Knox and Forrestal read the enclosure, agreed with its intent and Secretary Knox signed it into action on 12 July 1941 as General Order #150 setting up the Office of the Coordinator for Research and Development, in the Office of the Secretary of the Navy. Knox persuaded Dr. Jerome Hunsaker, who was already serving as Chairman of the National Advisory Committee on Aeronautics, to serve as the Coordinator of Research. In Hunsaker, the Secretary acquired the immediate services of a brilliant aeronautical and mechanical engineer who had designed the NC4 flying boats and the Navy dirigibles which served in the Thirties. He was a graduate of the U.S. Naval Academy, a professor of aeronautical and mechanical engineering at M.I.T., and he served as the first Director of the Department of Aeronautical Engineering at M.I.T. Dr. Hunsaker set up the Office of Coordinator of Research and Development (OCRD) to be responsive to Navy requirements for research and development, providing a channel of communications between the Navy and the Office of Scientific Research and Development, the National Defense Research Committee and the National Advisory Committee on Aeronautics, the Army and the United Kingdom.[4]

Hunsaker was a man of action experienced in the task of translating science into useable technology and then into hardware that could perform useful work. He recognized that one of the first actions required of the Office of the Coordinator of Research was to define the capabilities of the Navy laboratories. He needed to know, in 1941, if the laboratories could meet the approaching challenge for Navy's wartime requirements. He was fortunate to get, as his deputy, an excellent U.S. Navy engineer, CAPT Lybrand P. Smith and another excellent naval officer, CDR E. Wallace Sylvester, as Officer in Charge of the Progess and Planning Section. He acquired the sevices of four carefully selected young naval reserve officers, recruited from industry, education and patent law practice. He sent them out to various naval R&D laboratories to ask questions about operations and capabilities and because they were ferreting out information for him he dubbed them his "Bird Dogs," a name which persisted, becoming a badge of historic authority and pride. It continues to be a title of distinction because of the role the "Bird Dogs" played in the genesis of the Office of Naval Research.

The Office of the Coordinator of Research and Development had unusual access to the centers of power and action in Washington, D.C. as soon as it came into being because of Jerome Hunsaker's excellent reputation and political sophistication. He continued to serve as Chairman of the National Advisory Committee for Aeronautics and as a member of the Council of the Office of Scientific Research and Development. He moved in the center of Washington action for wartime emergency planning and in doing so drew his staff into the center of action also. They were present at many meetings and conversations of the decision-makers of U.S. World War II policy and plans. They were exposed to an illuminating spectrum of ideas about the role of research in building strong national defenses and how that research should be organized and conducted. Hunsaker wanted to make sure that his staff attended, as his assistant or alternate, the meetings in Washington at which weapons research and development programs were being discussed. The result was a daily education in Washington politics and policy-making activities. The Bird Dogs came to the challenge of their assignments with intellectual and emotional capacities equal to the expectations of Dr. Hunsaker when he selected them for his staff.

3. Letter from file of Dr. Bruce Old is dated 27 June 1941, signed by Dr. Jerome Hunsaker, includes statements anticipating the Office of Naval Research in its recommendations for long range research to continue in spite of the developing emergency, for a central organization, a Coordinator (leader) of naval research and other ideas which were later incorporated into the charter of the Office of Naval Research.

4. For mail purposes, the personnel of the Office of Coordinator Research & Development (OCR&D) used a code name "SONRD" which meant "Secretary's Office Naval Research and Development". In some cases, the code names OCR&D and SONRD have been used, interchangeably, and the practice causes some present day confusion of office title. It may be seen, from time to time, in print as "Office of the Coordinator of Naval Research & Development" an incorrect readout of the in-house Navy title.

Window Two

Emergence of the Concept

Who were these Bird Dogs that were called to active duty by Dr. Jerome Hunsaker and went on, later, to play such a unique role in the emergence of the Office of Naval Research? They were—by their own admission—brash young naval reserve officers called to active duty in August of 1941, from positions in industry, law and education. Dr. Hunsaker personally screened nearly 100 records of candidates selected from hundreds of prospects who were considered. From 25 of the 100 records, a smaller group was chosen to be interviewed and from those interviews Hunsaker chose four reserve officers to be on his staff in the Progress and Planning Section in the Office of Coordinator of Research. The four men were: Lieutenant Thomas C. Wilson, a physicist; Lieutenant H. Gordon Dyke, a patent attorney with a technical education; Ensign Ralph A. Krause, an electronics and communications expert; and Ensign Bruce S. Old, a chemical and metallurgical engineer. Those first four were assigned to the office in August of 1941. The other two Bird Dogs came later. LT John T. Burwell, a research physicist was assigned to the office in April 1942. LT James H. Wakelin, the sixth Bird Dog, came to the staff in December of 1943 and subsequently relieved LCDR Wilson in May of 1944.

"Soon after our arrival in the Office of the Coordinator of Research"—Krause and Old said[5]—"We were told by Dr. Hunsaker to go down to Annapolis and take a look at the Naval Engineering Experiment Station. When we came back, he asked us to write a critique of the laboratory and let him know if the laboratory could be of any use to the National Defense Research Committee in its contemplated major wartime R&D programs. This came as a surprise, and we asked him why he didn't tell us that's what he wanted before we went down there." We told him, "We have got to visit again before we can answer that question," so he said, "OK, go down again." We ended up writing a one-page memo about the laboratory in which we reported that they didn't do research work . . . they tested equipment, implying they would be no help to NDRC as they were presently set up. We signed the memo and learned several days later that it had gone through the chain at the Bureau of Ships, initialled by all the Admirals to whom the laboratory reported. When we learned that, we imagined that our little Ensign throats would be cut, either by the Admirals or by Hunsaker. Instead, Hunsaker said "Oh, I just postulated that if two dumb Ensigns could figure the Lab wasn't capable of performing research, then it ought to be obvious to the Admirals."

5. As told to ONR Historian, during Oral History taping sessions with Bruce Old, June 30, 1985. Tape is stored with Oral History Program tapes from interviews with R.D. Hagen.

The staff of the Navy's Coordinator of Research and Development at the close of World War II. Included in the photograph are the "bird dogs" who were instrumental in establishing the Office of Naval Research in 1946. The names of the "bird dogs" appear in bold print. Standing left to right: LT A. C. Body, LCDR N. S. Bartow, ***LT James Wakelin,*** *ENS Betty Cowie, LT James Parker,* ***LT Bruce Old, LCDR John Burwell.*** *Seated:* ***LCDR Ralph Krause,*** *CAPT Lybrand Smith, RADM J. A. Furer, CAPT S. F. Smith, CDR R. D. Conrad,* ***LCDR H. Gordon Dyke.*** *Another "bird dog" LT Thomas Wilson does not appear in the picture.*

Over a period of time, the four officers, Wilson, Dyke, Krause and Old were sent on successive missions to examine the operations and facilities of many Navy laboratories. When Hunsaker had their reports in hand, he occasionally used them to strengthen his own arguments that changes were required in the way research and development activities were being conducted at some places and that facilities and equipment were inadequate to serve predicted requirements of an emergency looming over the horizon. In reality—the Navy laboratories had been neglected over the years of low appropriations following World War I.

It was not only the investigation of laboratory operations which occupied the time and energies of the Bird Dogs. There was an urgent requirement for the Coordinator of Research and Development to know what R&D work was in progress or being planned at agencies both inside and outside the Navy. The task of inventorying what research was underway within the Army, Navy and United Kingdom laboratories, what university and industry laboratories were capable of undertaking sophisticated R&D, and what requirements the Army and Navy were formulating for new weapons and instruments of warfare was a colossal undertaking. OCR&D participated in this work with the NDRC and OSRD. This activity was assisted by the ruling of Secretary Knox, in October 1941, that all R&D projects which Navy requested NDRC to initiate must clear through OCR&D. The Office had the responsibility to see that the Navy had a proper liaison officer on each project in which it had an interest—whether funded by the NDRC, Navy or the Army. In many instances, this meant the OCR&D staff had to attend meetings and monitor the progress of programs. Over the years, the staff acquired knowledge of hundreds of important R&D programs as annual federal research and development expenditures climbed, under direction of the NDRC, and then OSRD, from a little more than 81 million dollars in 1940 to over 706 million dollars in 1944.[6]

The projects monitored included submarine and surface warfare, amphibious warfare, air warfare, and land warfare. OCR&D became involved in all the key developments such as radar, proximity fuzes, homing torpedoes, fire control, new explosives and propellants, etc. Often, the Bird Dogs acted as Secretaries of committees and had to initiate activities. For example, Krause, acting as Secretary of the Joint Committee on New Weapons ad hoc Committee on Radar Research and Development, played a key role in establishing the radar countermeasures research laboratory at Harvard.

OCR&D also established a link with intelligence activities in order to steer various countermeasure research work. Burwell was active in interrogating German submarine prisoners in order to evolve countermeasures to new homing torpedoes. And Bruce Old participated in the first ALSOS Mission, in 1943, to Italy to determine whether Hitler was developing an atomic bomb.

After 7 December 1941 and our declaration of war against the Axis, there was a tremendous surge in the activities of research and development. On 13 December, just 6 days after Pearl Harbor was attacked by the Japanese fleet, Jerome Hunsaker left as Coordinator of Research and Development to devote more time to his job as Chairman of NACA and was replaced by Rear Admiral Julius A. Furer. Hunsaker's influence continued to be strong in the Office of Coordinator, a highly positive force assisting Navy R&D plans and programs. Rear Admiral Furer was a graduate of the Naval Academy in 1901 and took a Master of Science degree from M.I.T. in 1905. He was an engineer with extensive experience in ship construction and in the planning and installation of all kinds of machinery. He understood the high value of research to the Navy and he comments in the opening words of his Memorandum[7] to the Assistant Secretary of the Navy, dated 26 February 1945, "Due to our comparative neglect of research prior to the war, the Navy was faced with the urgent task of improving its weapons, creating new ones, and of providing countermeasures to new weapons and methods of warfare being revealed by Germany. It was a stupendous undertaking."

Furer was a very capable naval officer and he accepted this challenging end-of-career responsibility with apparent interest and determination to be of good service to the Navy. He must have felt some frustration from the absence of genuine authority in the charter of the Office of Coordinator because he mentions it to Secretary Knox in a description of his job functions.[8] He was acquainted with the political exigencies that help so much to accomplish objectives when authority is not indisputably chartered. Furer continued to task the Bird Dogs as Hunsaker had done, to investigate the capabilities of Navy laboratories to respond to the Navy's wartime requirements for research and development. It was a tasking laced with hazards for young naval reserve officers in a mission which gave the appearance of raw criticism levied upon seasoned, dedicated career officers. The Bird Dogs were greeted,

6. Figures are taken from the U.S. Senate "Excerpts from Report from The Subcommittee on War Mobilization to the Committee on Military Affairs, United States Senate, dated July 1945, Part II—Findings and Recommendations" Page 3 presents a schedule of which federal agencies spent which dollars during the years from 1937 thru 1944 for research and development work.

7. The Memo dated 26 February 1945, presents an exceptionally well documented case for consideration of an ONR-like office. This quote appears in Part 1.

8. In the Memo to Assistant Secretary, 2/26/45. In Exhibit H, Para #5, Furer says: "The duties assigned to the Coordinator of Research and Development by General Order #150 are stated only very loosely and somewhat vaguely and have had to be given broad interpretations as experience dictated in order to carry out the intent of the Order. For this reason, results have had to be achieved by persuasion rather than by directives."

from time to time, with unmasked hostility and palpable implications of insubordination voiced in demands for evidence of credentials to fulfill their mission.[9] At other times, in their admittedly brash manner of behavior, the Bird Dogs resorted to a variety of techniques for getting the information they were tasked to find, staying just slightly ahead of such drastic action as being thrown out, bodily, from offices or from the Navy. The system worked, however, and provided an invaluable service to the Coordinator of Research and Development. It was this exposure to a full spectrum of problems and successes in Navy research plans and programs that opened furrows in fertile ground for seeding the concept of the Office of Naval Research in the minds of the Bird Dogs, as well as others equally concerned about the problems of the day. There was a steady growth of awareness, among the Bird Dogs, that something should be done to strengthen the Navy's research program and they believed they were capable of making a contribution to efforts for reaching that goal.

By December of 1942, Ralph Krause and Bruce Old had met Professor George B. Karelitz, on leave from Columbia University, working at the Bureau of ships during the wartime emergency. Professor Karelitz, a former naval officer in the service of Nicholas II, last Czar of all the Russias, had made his way to the United States after the revolution and brought to an intellectual relationship with Krause and Old some excellent ideas about Navy planning and organization. The three men began meeting on some evenings in the living room of LT Old's home, 2102 South 27th Street in Arlington, Virginia, to talk about things that might be done to improve the Navy's research activities for both present and future requirements. In the minutes[10] of their first meeting, dated 14 December 1942, 8:00 P.M., the three concerned inquirers record the following statement:

"It was agreed that the first question which must be answered when considering the establishment of a research organization is, 'Why do we need research?' Unless it can be proven that research is essential to the well being of a Navy, there is little hope that research will survive periods of National economy." They went on to phrase a definition of why research is important to the Navy, incorporating into their statement two significant reasons for a research program: "1. Foreign military scientific developments must be countered, and 2. In order to insure national safety our military scientific developments must maintain superiority over those of foreign countries".The minutes go on to list specific foreign technologies advances which have forced the Navy into research.

They go on to state that Navy should carry out its own research and development and not depend on industry, including the observations that; 1. During wartime production, industry is too involved in production to perform adequate military research; and, 2. During peacetime economy there is insufficient profit motive to warrant industry undertaking military research." The minutes are closed with a statement that anticipates an Office of Naval Research, albeit the phrasing calls it "the organization of post war Navy research."

Professor Karelitz died in 1943, several months after the three men began their discussions. It denied Krause and Old the highly valuable guidance shared by Karelitz, but they continued to work on a formulation of a Navy research system that would assign authority and importance to the task of laying a foundation of scientific knowledge of service to future naval requirements. They brought into their discussion group another Bird Dog, John Burwell, who was equally interested in the problem.

Window Three

The Concept Begins to Take Shape

In a memorandum to Vice Admiral F. J. Horne, the Vice Chief of Naval Operations, dated 23 September 1943, Rear Admiral Furer expresses his concern about what will happen to Navy research after the war is over. In the memo, he suggests a revision of General Order #150 to strengthen the Office of the Coordinator of Research and Development. The memo also proposes that the Naval Research Laboratory be transferred back to the Office of the Secretary of the Navy. It is an interesting historical note that in the memorandum, Rear Admiral Furer uses the term "Chief of Naval Research," thereby assigning the job status equal to the Chiefs of the Bureaus and it becomes the first official use of the title, Chief of Naval Research.[11] The focus of Jerome Hunsaker's efforts to set up the Office of the Coordinator of Research and Development had been to strengthen the Navy's research programs, and his labors had accomplished much. However, it was not a simple action to get the Bureaus to give up any of their research tasks. As with most dedicated managers, it is a matter of

9. Bruce Old tells about going to Navy Bureau of Ordnance to recommend that they establish closer liaison with NACA who was doing advanced work on gas turbines. The Captain in charge of research said, "Who do you think you are, coming in here to tell BUORD how to conduct its research... What office are you with?" Whereupon Lt. Old told him OCR&D. The Captain demanded the General Order and was told #150. The Captain then said get me the Navy Regs and Lt. Old said, "I'll quote for you...it says our office is to advise the Secretary of the Navy on research. We interpret that order very broadly."

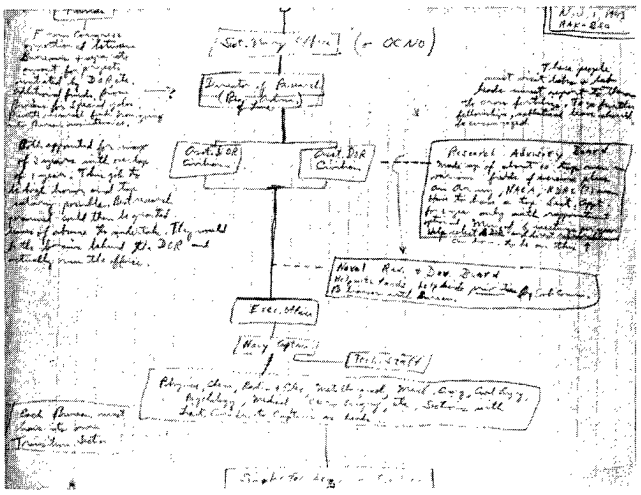
10. Minutes loaned by Dr. Bruce Old to ONR Historian. Copies are held by ONR Historian. 3 pages of typed information constitute the minutes of meeting.

11. The title Chief of Naval Research was written into the Congressional Bill, #588, which established the Office of Naval Research in 1946 and remains to this date the title of the Head of the Office of Naval Research.

grave concern to release to somebody else any elements of control which have traditionally assisted leadership in achieving important objectives. Furer's attempts to strengthen OCR&D and to describe a long term requirement for naval research planning was put aside for the moment, partly because Admiral King was opposed to investing the Secretary of the Navy with more power at that time.

On 2 October 1943, Under Secretary Forrestal requested of Mr. R. J. Dearborn, President of Texaco Development Corporation and Chairman of the Committee on Patents of the National Association of Manufacturers that he "survey the policies and procedures of the Navy Department with respect to patents and inventions." The Dearborn Report[12] recommended, on 10 March 1944, that there be established an Office of Patents and Inventions to protect both Government and the private citizen in work accomplished for military research and development. The report set the stage for the establishment of the Office of Patents and Inventions on 19 October 1944.

In November of 1943, the Bird Dogs had begun to draw organization[13] charts to illustrate their concept of an office which they believed would properly serve Navy needs for a strong research program. The charts were expressions of many possible solutions to the problem of how to centralize and strengthen naval research activities and objectives. They drafted many written plans that became progressively more precise in their statement about how a central naval research organization should look. What may well be the first of the charts, dated 1 November 1943 and initialled RAK-BSO,[14] reveals an organization wired directly into the Office of the Secretary of the Navy and descending from that summit to a Director of Research shown as (Rear Adm. of Line). Next down the chain of administration are shown two Assistant Directors of Research, both marked civilian, on an equal plane with a dotted line connection to a Research Advisory Board which presages the Naval Research Advisory Committee (NRAC). Funding is shown coming from Congress, with equal sharing between the Director of Research and the Navy Bureaus. The handwritten chart is especially interesting because, it appears to be the earliest diagram, available, of the Office of Naval Research, in its embryonic state.



Organization chart, 11/1/43

On 23 September 1944, the Bird Dogs, using the traditional privilege of sending a beneficial suggestion directly to the Secretary of the Navy, sent a memorandum to Forrestal, via RADM Furer, which lays out in detail a plan for the naval research program organization. They were confident at this point that RADM Furer would not move in such a direction because of the Secretary's rebuff of his proposal for a central organization in 1943. The Bird Dogs were too deeply involved in selling the ONR concept to seriously consider the outcome of this brash move they were about to make. However, when it got to the desk of RADM Furer—as Dr. Old has told me: "He blew his top, as he thought this put him in an awkward position. He requested we re-write the same suggestion to go over his signature to the Secretary, and we acquiesced." Thus, on 11 October 1944, Rear Admiral Furer signed a memorandum to the Secretary recommending immediate establishment of a central research organization answering through an Assistant Secretary of the Navy for Research. Instead of acting on that suggestion, Secretary Forrestal established, nine days later on 19 October 1944, the Office of Patents and Inventions with Rear Admiral H. G. Bowen in charge.

There was a war in progress and nobody had time to leisurely sit around and contemplate the character of naval research after the war. The Bird Dogs had individual responsibilities in the OCR&D Planning Branch which occupied their time and energies. Thinking about an Office of Naval Research had to be sandwiched in at times when they were in Washington, could momentarily put aside their wartime responsibilities and get together for conversation. However, by the beginning of 1944, the Bird Dogs had strongly fixed their sights on an objective of seeing this plan through to its

12. Copy held by the ONR Historian. The Dearborn Report set the stage for the establishment of the Office of Patents and Inventions on 19 October 1944. A letter from the Secretary of the Navy, Forrestal, dated 7 October 1946 expresses appreciation to Mr. Dearborn for his survey of the patent and research situation of the Navy. Forrestal goes on to say that Dearborn's work set the charter for the "present Office of Research and Inventions" which has to be a slip of meaning because ONR was established and incorporated the Navy's responsibilities for patents by the time the letter was written, 7 October 1946.

13. Copies of two drafts of organization charts are held by the ONR Historian, by permission of Dr. Bruce Old, from his file.

14. The chart dated 11/1/43, initialled by RAK-BSO, is handwritten on a piece of lined tablet paper, included in the documents loaned by Dr. Bruce S. Old to the ONR Historian. It exists as a detached paper, copied by ONR Historian for keeping with other copies of Dr. Old's papers loaned.

fruition—of championing the cause for a central naval research organization that would serve the Navy better than the organization in which they were presently working, the OCR&D. They had access to Hunsaker, to Bush and to Jewett and Compton because they attended the meetings of NDRC and OSRD as recording secretaries or representatives of OCR&D. They took many opportunities to discuss their ideas about a central naval research organizations with them. Simultaneously, of course, there were other ideas being discussed apart from those of the Bird Dogs. Rear Admiral Bowen was equally concerned about post war research and his concerns, genuine as they were, found expression in some political moves within the Navy to strengthen his position for achieving various naval research goals of his own definition.[15]

By the Spring of 1944, an end to the war appeared over the horizon and many who had dedicated their time and energies to winning the war were starting to think about resuming peacetime careers. Dr. Bush talked openly with the members of the OSRD about requirements for conducting research without the powerful support which OSRD had been bringing to wartime management of research. He reminded all of them that as soon as the war would be over, OSRD would probably disappear and the scientists who had rallied to the cause would go home to their individual research projects—away from the military research that had so fully occupied their time and thought. Rear Admiral Furer and the OCR&D staff had been working with genuine determination for a long time at the concept of a central naval research organization that could strengthen the Navy's research program. Motivated by the implications of the absence of an OSRD in the approaching future, Furer asked for a conference about the future of military research to which he invited the top research people from the Navy, the Army and OSRD. They came—43 people, Army, Navy and civilians—all interested to share information about this momentous issue of post-war research. The outcome of this meeting was the appointment of a committee by Secretaries Forrestal and Stimson to explore possibilities for maintaining a strong military research program after the war. Charles E. Wilson, Vice Chairman of the War Production Board, was named Chairman of the Committee on Post-War Research which began its meetings on 22 June 1944. From the meetings of the Committee came a recommendation that there be established an organization that would function as an independent research agency.

On the 9th of November 1944, Secretary Forrestal and Secretary Stimson signed out a letter[16] to the President of the National Academy of Sciences requesting that a Research Board for National Security be established to take the place of the Office of Scientific Research and Development, a temporary, wartime emergency agency. In the opening of the letter to the Academy, three facts of supreme importance to national security are given recognition: "1. Powerful new tactics are developed around new weapons created by scientific and engineering research, 2. Competitive time elements in developing those weapons and tactics may be decisive. 3. War is increasingly *total* war, in which Armed Services must be supplemented by active participation of every element of the civilian population." It goes on to declare that peactime science is essential to our defenses—that "the research scientists of the country must be called upon to continue in peacetime some substantial portion of those types of contribution to national security which they have made so effectively during the stress of the present war." The letter reveals a recommended charter which included the following statement of duty: "It shall be the duty of the Board to formulate programs of scientific research and development relative to problems of national security, to direct and conduct the scientific study of such problems and to advise the Secretary of War and the Secretary of Navy on the applications of science to national security." The letter presents a list of proposed members of the committee and an executive committee of three persons headed by a Chairman, Karl T. Compton who was then President of Massachusetts Institute of Technology.

The President of the National Academy of Sciences, Frank Jewett, asked Karl Compton to serve as Chairman of the Research Board for National Security and Compton responded in a letter[17], dated 4 December 1944, that he would accept the Post, with reservations. The first was acceptance of the Post contingent upon Dr. Bush's approval because as Compton says, "I have already obligated myself in several capacities in the OSRD organization." The second reservation was explained in a lengthy statement of Compton's concern that the Research Board for National Security might drain away the very scientific talent and energy needed to bring us to victory against the Axis and that, too soon, too many people were ready to turn their time and energies to non-military research. He did not want the new organization to compete with OSRD and in that way weaken its already demonstrated abilities to respond to emergency requirements. Nonetheless, he accepted the Chairmanship for this organization which turned out to be very short-lived because there were several Bills before Congress which called for research organization of national stature and the Bureau of the Budget decided not to transfer funds for the functions

15. An account of activities of Rear Admiral Bowen is given in the draft of ONR history by Professor Harvey Sopolsky of M.I.T.

16. A copy of the letter is held in the files of the ONR Historian.

17. Copy is held by ONR Historian. Compton makes a very strong point of defining his terms of acceptance as Chairman as linked to recognition that the new organization, the RBNS, should not take anything away from OSRD before the war is actually won and peacetime research can be planned without jeopardizing victory.

of RBNS. On the other hand—the short life of the organization helped, greatly, to crystallize the thinking of Congressmen and military personnel about post-war research with its special needs and benefits.

Those were stimulating times for the Bird Dogs because their concepts about the Navy's post-war research program were being influenced by the high level decisions around them. They were privileged to hear the actual exchange of words in the meetings they attended as recording secretaries or as representatives of Navy's OCR&D. Their education was swift and forthright—no second hand information. They were getting it straight from the source. Burwell, Krause and Old had suffered a temporary defeat in their campaigns to win over support for the evolving Office of Naval Research but they persevered, not willing to abandon what they perceived to be a worthy goal. Typical of the inside information they frequently shared came as a bit of news one day from a naval reserve officer friend who was Admiral King's mail clerk. They learned that President Roosevelt had rejected a plan by Admiral King to reorganize the Navy with a handwritten note which said, tersely: "Ernie—I made you COMINCH to fight the war, not to reorganize the Navy Department—FDR."[18] The Bird Dogs decided that the White House had to be the place to go with their case for a central Navy research organization. After all, they had gained the attention and approval of their plan from both Hunsaker and Bush, personally, having shown them the suggestion of 23 September 1944 in their beneficial suggestion to the Secretary of the Navy.

In a memorandum[19] dated 26 October 1944, Lt. Comdr. Bruce Old, Krause and Burwell, authored a "Proposed Organization of Research in the Navy Department." The memo presents a lengthy statement about the reasons for establishing a new position, that of Assistant Secretary of the Navy for Research. A detailed job description is provided, explaining the kind of person who would be right for the job and what responsibilities the position would embrace. The memo reads, " . . . In order for the Navy to maintain the best possible liaison and receive the maximum amount of benefit from this vast amount of work, it is necessary that the head of Naval research be a man known and respected throughout the country as an emiment scientist who could obtain the cooperation of the scientists of the Nation in furthering the scientific readiness of the Navy." The position of Director of Naval Research is proposed as a Flag officer with rank equal to that of the Chiefs of the Material Bureaus and, "should be selected with particular regard to qualities of initiative, imagination, technical training, and knowledge of naval operations." In addition, "The Director of Naval Research would report directly to the Secretary of the Navy, (through the Assistant Secretary for Research) but would have additional duty as necessary in the Office of the Chief of Naval Operations in order to provide close liaison between research and war plans and Fleet operations." The Plan calls for a Deputy Director, placement of the Naval Research Laboratory under the new organization and for a Director of Patents.

It is a plan of specific definition for a naval research organization that is a direct forerunner of the Office of Naval Research, without mention of the Naval Research Advisory Committee that occupied an important place in the concept of the authors but is not described in this memorandum.

By November of 1944, President Roosevelt had reason to feel a strong measure of confidence about victory for the Allies. In conversation with Dr. Bush about post-war military research he asked questions of Bush concerning reconversion and was prompted to put down questions in a formal statement. In a letter dated 17 November 1944,[20] Roosevelt commented on the importance of sharing lessons learned from the operations of OSRD. He posed four questions about how our nation might benefit from: 1. scientific knowledge gained in the development and production of weapons for winning the war by sharing it and turning it into information useful for "improvement of the national well-being." 2. What can be done to continue the war against disease by organizing a program "for continuing in the future the work which has been done in medicine and related sciences?" 3. "What can the Government do now and in the future to aid research activities by public and private organizations?" and, 4. "Can an effective program be proposed for discovering and developing scientific talent in American youth so that the continuing future of scientific research in this country may be assured on a level comparable to what has been done during the war?" It is a source of some quiet excitement to the author to read the letter and examine in this statement a stunning new outlook on science and research from a President of the United States. It echoes a growing hue and cry heard in 1944 for the praises of science and what could be done to improve the human condition. It reflects the President's recognition that our nation's future would need to be closely linked to and highly dependent upon the burgeoning concepts of advancing science and technology to help us to realize multiple national and international objectives.

18. The account of the response to ADM King from FDR is included in the article by the Bird Dogs, published in Physics Today, August 1961.

19. The memo presents an excellent, almost impassioned, justification for the establishment of an Office of Assistant Secretary for Research in the Office of the Secretary of the Navy, pointing out that the importance of research in private industry has evolved to appointments of Vice Presidents who answer directly to the Chief Executive Officer of private companies. It also declares that assurance is received that at least 25 of the most eminent research directors in the U.S. would gladly testify in favor of the Navy Department following this procedure.

20. Copy is held by the ONR Historian.

Vannevar Bush acted, immediately. In a memorandum[21] to the Advisory Council of the OSRD, dated 18 November 1944, Dr. Bush informs the Council members of the request from the President and reviews the four questions that need to be answered. He requested the members submit to him their recommendations for a response to the President, saying " . . . In view of my immediate absence from the city, and the urgency of promptly formulating a sound program on the last two problems referred to by the President."

The full response from the Office of Coordinator for Naval Research and Development to F.D.R. via Dr. Bush came in rough draft form from the hand of Captain L. P. Smith, who was RADM Furer's deputy OCR&D. RADM Furer had strong feelings about these issues and they are incorporated into the memo, as they had been in memoranda and letters during previous years of his efforts to define a central naval research organization. The rough draft copy[22] confines itself to answering the 3rd and 4th questions of President Roosevelt. The answers are revelations of things to come and an unexpected insight into some social problems present in groups mixing scientists and military personnel. The memo quotes Dr. Conant, from remarks Conant made when he accepted the Priestly Medal: "Ten second-rate men are no substitute for one first-class man. It is no use pouring second-class men on a problem even if you are under the greatest pressure for a solution; second-class men often do more harm than good." Furer says, "I thoroughly concur with that statement and, therefore believe that any public research organization must offer an attractive career to young and enterprising research personnel." He describes the need to make sure that young naval officers, as well as young civilian scientists, have an opportunity to improve their education and be encouraged to pursue careers in naval research. There is an interesting exploration into the cause and effects of social status which reads like a disclaimer that military officers are snobbish and exclusive in relations with civilian employees of federal government agencies. Its true interest lies in its intent to illustrate the importance of assigning worthy social status to research personnel, in whatever social group they work, so that research careers will be properly encouraged. There is a very cogent argument for establishing a position of Head research person who has direct and immediate access to the Chief Operating Officer of a company or organization so that production people cannot get into the research process and siphon away funds or talent to focus research on one project, to the detriment of long-term research work. He mentions an Assistant Secretary of the Navy for Research at this point as an illustration of the level recommended for a research leader. There is a very direct statement concerning advisability of the Government owning and operating research facilities, highlighted with two examples: (a) When it is imperative for some governmental activity to have complete control of the research facilities, and (b) Where research facilities can be of general use in civil life but are far too costly for any one industry to undertake. The most abbreviated section of the rough draft response is in answer to the fourth question which inquires about discovery of and encouragement of scientific talent in the young people of America. He applauds the scholarship programs of private industry and others which have launched careers in science and he recommends the grants be continued. The Memo anticipates that there will be universal military training after the war and that young people could be screened during such training for aptitudes in science. We search, today, for those same answers . . . How do we act to encourage and create genuine interest, stimulating enough for young people to prompt them to complete their difficult preparation for scientific research and go on to careers as investigators of basic science in a rather dedicated life which often demands denial of some things but promises tantalizing rewards of dramatic achievement in advancing scientific knowledge and improving the human condition?

Rear Admiral Furer and his staff presented, in this memorandum being prepared for Bush, a package of ideas that had been evolving from repeated conversations about naval research activities throughout the war. They were at the hub of those activities and had been educated most fully and often unkindly in the process of how research must be conducted . . . how it springs from special requirements or thought processes . . . and how it can be confused or sidetracked by urgencies incorrectly perceived at all levels of decision. Because of the renewed conversations about winding down OSRD, the Office of Coordinator of Research and Development was seen as possibly living on borrowed time, and provision needed to be made for the future of naval research. Furer was apparently frustrated with the maneuvering in the Bureaus, at the Naval Research Laboratory and other offices to protect prerogatives and controls of programs supplying the Fleet with all its wartime requirements. However, he grasped every opportunity to continue his campaign for a proper naval research organization that would serve future requirements of the Navy.

In a memorandum[23] to the Vice Chief of Naval Operations, Vice Admiral Horne, dated 27 November 1944, Furer refers to a memo of a year earlier in which he argued the case for a central research organization

21. Copy held by ONR Historian.

22. The copy held by the ONR Historian, bearing the initials LPS, is a rough draft entitled "Memorandum for Dr. V. Bush, Director of OSRD."

23. Copy of the memo is held by ONR Historian as enclosure "Exhibit J", in the package of information sent to the Assistant Secretary of the Navy with the cover memorandum dated 26 February 1945.

and now wants to bring his views on the subject up to date for VCNO. It is an impassioned mixture of facts and recommendations which reveal familiar problems and hopes for solutions. He begins with a declaration about the service his office (OCR&D) has been providing throughout the war and credits its fine record to the unusual performance of his staff of young officers who "carried out my policy of doing the work by persuasion rather than by issuing orders." He goes on to say, "There are, however, signs that the mechanism of coordination established by General Order No. 150 is deteriorating and is losing the support of the Bureaus as they see the end of the war approaching. Under the pressure of war the Bureaus were not so jealous of their prerogatives as they normally are in times of peace. With the demobilization of OSRD at the end of the war, the position of the Coordinator's Office will be further weakened." Going on with his comments about his concerns, Furer points out that two logical amendments to General Order No. 150 have been turned down by the Bureaus, one to require the Bureaus to keep the Coordinator's Office informed of all research and development contracts placed by them, and two, a requirement for all proposals for the establishment of new research activities, laboratories, stations, etc., or for abolishing any such establishments, to be routed to the Secretary via the Coordinator. It ends that statement with, "Both are logical requirements if there is to be genuine coordination of the Navy's research activities."

The memo continues with a comment that there seems to be universal agreement in Navy, Congress and among industrial and scientific leaders that military research during the peace period must be stressed beyond almost any other part of the post-war preparedness program. Furer says, "This certainly requires that research must be made the function of some individual, or Office, in the Navy Department. He discusses the Sheppard Bill[24] which proposed setting up an Office of Research and Development in the Navy Department." He describes it as providing strong centralized control which . . . "will not be satisfactory to the Bureaus because they will consider that it encroaches on their prerogratives even more than does General Order No. 150."

The next proposal is the one which always seemed to disturb the general Navy establishment . . . the establishment of a new position in the Secretariat, an Assistant Secretary of the Navy for Research. RADM Furer comments that he has made such a recommendation to the Secretary and encloses a copy[25] of the memo. His frustrations must have been considerable because he goes on to say that while these proposals would require Congressional action, such action may never come because of opposition from the Bureaus. The text which followed indicated such frustration when he says, "In my opinion, the basis for Bureau opposition is always the same: it is feared that veto powers will be exercised against research work which, in their judgement, the Bureaus consider essential to fulfill their responsibilities. The proposed amendments to General Order No. 150 were turned down, I feel sure, because the Coordinator might interfere with work which the Bureaus have in hand or their plans for building up Bureau laboratories."

Having expressed those sentiments, Furer goes on to say that since none of the two plans discussed are close to realization, the immediate problems is how to keep the Coordinator's Office alive. He proposes a plan for transferring the Office from the Secretariat to the Office of the Chief of Naval Operations and recommends the idea of calling it a DCNO(R).

Window Four

Victory for the Allies—and for Naval Research

The Office of the Coordinator of Research and Development is where research was supposed to be encouraged and nurtured—the place where coordination was to take place with OSRD, with NACA, with NDRC, with the Army, the United Kingdom and with the Navy Bureaus, and it did. But we know from Furer's papers and from the papers and conversations of the Bird Dogs that whatever coordination took place was by that most effective of all authorities in situations of rapidly changing requirements and urgent actions—the personal touch—persuasion and logic. However, the glue which held such actions together and permitted continued success, without written directives or enabling statements, was the spirit of cooperation and sacrifice pervasive in personal social and business relationships during the war and in the nation's vision of victory. Once that would be history, the cooperation could very well be replaced with competition on a new scale. That was the spectre appearing over the horizon of Navy and National research planning for the future—who would provide strength and guidance for an exciting promise of wonders to come from science already discovered by the war effort and the marvels of new technology envisioned by scientists and engineers? The personnel of OCR&D were some of the most obvious spokesmen around for defining those issues.

24. Copy of the Bill (H.R. 5174) dated August 10, 1944, is held as enclosure "Exhibit L" in Furer's memo to Assistant Secretary of the Navy, 2/26/45.

25. It is the memo dated 11 October 1944, signed by RADM Furer which picks up the text of the beneficial suggestion of the Bird Dogs to the SECNAV, memo dated 23 September 1944 proposing, ONR.

At the beginning of 1945, Assistant Secretary H. Struve Hensel requested information from RADM Furer about OCR&D. In a package[26] that is introduced by a cover memo, dated 26 February 1945, from Furer to the Assistant Secretary, there is a collection of documents produced by the Bird Dogs, by RADM Furer and by other staff members of OCR&D which reports to today's reader a substantial slice of the saga of OCR&D and its struggle to strengthen naval research activities. The memo begins with a brief on the origins of OCR&D, . . . "established to meet an urgent need for the assistance of civilian scientists in the Navy's research programs. Due to our comparative neglect of research prior to the war, the Navy was faced with the urgent task of improving its weapons, creating new ones, and of providing countermeasures to new weapons and methods of warfare being revealed by Germany. It was a stupendous undertaking." The memo continues with a description of the mission and staff of the Office, a run-down on the work the Office has been doing, the biographies of the staff and then presents memoranda from the previous 3 years which clearly demonstrate the argument for an Office of Naval Research. The package includes, at the very end of the series of documents, the letter from President Roosevelt of 17 November 1944 in which F.D.R. asks for a plan in the post-war era to share the lessons learned in World War II with the nation and put our new science to work.

Whatever influence Furer's memo had on the Secretariat is not shared in this author's search of materials. However, we can assume that it got some considerable attention throughout the research establishment of the Navy. Rear Admiral Bowen's opinions were in better favor than they had been for a while and he was determined to have a role in planning post-war naval research. Secretary Forrestal had rejected the idea of an Assistant Secretary for Research months before and was still opposed to it. He acted, suddenly,[27] in May, to place his stamp of approval on the future of naval research planning by establishing[28] the Office of Research and Inventions, 19 May 1945, cancelling General Order No. 150 and 159 and appointing Rear Admiral Harold G. Bowen as Head of the Office of Research and Inventions.

RADM Bowen

What may be the last written communication with the Office of the Coordinator of Research and Development is a "MEMORANDUM TO THE COORDINATOR," dated 18 May 1945, just one day before the Secretary's notice establishing the Office of Research and Inventions. The memo is a report on the exchange of information with the British by Ralph Krause, the electronics expert of the Bird Dogs. The report is mainly concerned with various developments in radar that were shared between the United States and Great Britain throughout the war.

The birth of an idea which was carried to excellent fruition is discussed in a memo[29] that turned out to be a kind of Swan Song for Rear Admiral Furer and which reflects, so clearly, the exceptional insight into and perception of how naval research should be strengthened and managed. It demonstrates the skills and attitudes that were acquired through daily involvement in the resolution of research problems to satisfy wartime Fleet requirements or that were sensed intuitively by Furer and his staff personnel. The memo, signed out by Rear Admiral Furer on 21 May 1945, responds to a request for a study of navy research and a scientific corps. The request was directed to the Secretary of the Navy by COMINCH, Admiral King, in a memo dated 26 March 1945. Furer's memo makes another case for an Office of

26. Copy of package is held by ONR Historian, with a note clipped to the inside of the cover from an Assistant to Dr. Vannevar Bush, C. L. Wilson, to OCR&D which says: "Thanks very much for loan of this. The Chief (Dr. Bush) looked it over and read parts of it. A good job was done in putting this material together." The note is dated 5/29/45.

27. The Report which Secretary Forrestal had requested from Mr. R. J. Dearborn recommended an office of Patents and Inventions, which was established. It is a strong possibility that Rear Admiral Bowen influenced the Secretary to make the apparently sudden move from The Office of Patents and Inventions to the name Office of Research and Inventions.

28. ONR Historian holds copy of SECNAV Notice, dated 19 May 1945, announcing new Office of Research and Inventions, along with copy of orders for Rear Admiral Harold G. Bowen to assume duties as the Chief of the Office of Research and Inventions, 19 May 1945.

29. Copy is held by ONR Historian as an enclosure in a package of documents which cover actions of the OCR&D from its inception to its demise and replacement by ORI.

Naval Research in the mold of his former recommendations, in spite of the fact that ORI is already up and operating. The memorandum may well have been nearly ready for signature when the Secretary's decision about ORI was announced. The message is that the Navy needs to have a Corps of scientifically educated and experienced officers who will be capable of helping to make decisions about an increasingly complex arsenal of Navy weapons systems. He reminds the reader of the decisive role science had played in World War II and illustrates the high wisdom of our nation's choice in calling upon science to help us win the war. He says, "While it is generally accepted that it has been the contributions of science which have speeded up the tempo of modern warfare and which have made war so much more complex and destructive than ever before, it is not so generally realized that no belligerent in this war has as yet fully exploited the possibilities of science, particularly in war planning. Even Germany used her scientists capriciously. Had the German scientific organization not, in a large measure, been dispersed in 1941, we might be in a much less favorable position that we are today." He goes on to say, immediately, "If we are wise, we should, therefore plan to still further enlarge and strengthen the partnership between science and the Navy."

Furer writes, "A Corps of Scientists is needed principally to provide qualified officers for staffing:

a. in the organization of COMINCH & CNO

b. for staff duty with forces afloat

c. research divisions of the Bureaus & other Navy Department offices

d. in the laboratories, wherever research & evaluation is done

e. in Naval Intelligence organizations

f. in the Bureau of Naval Research . . . and adds at this point . . . "which will be referred to presently." He gets rights in there and drives home the requirement for a sponsor by saying, "A Corps of Scientists can perform these functions effectively only if sponsored by a bureau in the Navy Department. It is accordingly recommended that a Bureau of Naval Research be established by law as part of the Navy Department's organization, and that one of its duties be the sponsoring of a Corps of Scientists."

Next he recites the functions of a Bureau of Naval Research which have by this time become extremely well articulated:

"a. To formulate and adminster the research policy of the Navy;

b. To initiate and finance basic research projects not coming under the cognizance of any particular bureau;

c. To coordinate the research work of the Navy as a whole;

d. To exercise administrative supervision of the Naval Research Laboratory and any other similar facilities which are not logically a part of any single bureau;

e. To administer the Corps of Scientists and the Navy Scientific Reserve Corps;

f. To provide Navy representation or liaison on external research agencies;

g. To maintain records of all research being undertaken by the Navy; to keep central files of research data;
to publish a scientific journal;
to evaluate technical intelligence reports;
and to perform other similar services."

He goes on to talk about the need for a Scientific Corps of Naval Reserve Officers which would draw upon a great number of men who want association with the Navy to continue but do not want to have a lifetime career in service.

In the conclusion, the author of the memorandum recommends that "immediate steps be taken to draft suitable legislation by rewriting the Sheppard bill or by drawing up a new bill. A final statement expresses urgency about providing a way to keep naval officers interested to stay in the Navy after the war and become the Corps of Scientists needed by Navy.

Admiral Bowen's appointment as chief of the Office of Research and Inventions (ORI) was a pleasant triumph in his determination to gain control of naval research activities. Whatever his sentiments about the staff he inherited from Rear Admiral Furer, he recognized the merits of calling on performance and demonstrated results. Perhaps because everybody was very much primed to the concept of a Congressionally mandated naval research organization, Dr. Bruce Old tells us that soon after Bowen and DeFlorez arrived to take over naval research, the Bird Dogs and Captain Conrad made a successful pitch for consideration of the long-recommended Office of Naval Research, with authorization from Congress rather than from the Secretary of the Navy.

Window Five

The Call for Scientists

As the Office of Research and Inventions began to assume its responsibilities and to define the horizons of its charter, it became clear to many on the staff that the mere existence of an office to manage naval research could not assure access to people who actually conducted science projects and investigated scientific phenomena. It had long been a topic of prime concern

among the personnel of OCR&D that after the war, scientists would be eager to return to a more relaxed and private career in the research laboratories of the University Campus, in generous Foundations or industrial laboratories across the country—but out of Washington with its military controls that had been restrictive during the war.

Into this scene of concern looms the figure of a brilliant and quietly unassuming naval officer who becomes the articulator of the concept of the Office of Naval Research and the messenger of a new hope for science in the Navy, and in the United States . . . the bringer of good news. Captain Robert D. Conrad might even be called the "Renaissance Man" of his time. He took upon himself the responsibility of explaining the mission of naval research in the exploration of the fundamental nature of our world and our universe.

Captain Robert D. Conrad

Captain Conrad had served with distinction, since June of 1942 with Admiral Furer and the OCR&D. He had arrived at the OCR&D from London where he served as Naval Attache for a year, a naval officer with an M.S. from M.I.T. in naval architecture. He had worked mainly in design and research for eleven years in the Navy. Conrad was accustomed to the Navy of the Bureaus, where research and development lived side by side and requirements from the Fleet were the driving mechanism for exploration of new science. Living from day to day with research problems that came to the OCR&D and the experience of close liaison with NDRC, OSRD and NACA, as well as the army of scientists so readily available to Navy requirements, was an education of unusual character. For an intellectual achiever like Robert Conrad it was a powerful force for change—a window out to a vision of future possibility for Navy excellence with advancing science and technology. He was also a mentor of the Bird Dogs, as Head of the Progress and Planning Branch in which they served at OCR&D. His own concepts about naval research management began to change as he dealt with the problems of wartime response to rapidly changing fleet requirements. The interplay of ideas among the personnel of Coordinator's Office had a broadening influence on each of them. They clearly recognized the essential requirement for basic research to provide advantage for Navy operators at sea by giving them something better than the adversary had; it must be there to serve the future, even though it was too late for this war.

On 5 July 1945, Dr. Bush delivered to President Truman the report that had been requested of Bush, as Director of OSRD, by President Roosevelt in November of 1944. Entitled, "Science, The Endless Frontier," it is often considered, still, to be the definitive statement on national research requirements and methods for satisfying them. It clearly describes our nation's urgent requirements immediately following World War II, and it presents a model for the National Science Foundation. In the opening of the Summary[30], the report says, "Interest in the question of Federal aid to research reflects widespread recognition by the American people that the security of a modern nation depends in a vital way upon scientific research and technological progress." Under the subtitle, "A National Research Foundation," it reports, "We believe that our national and international needs and responsibilities in the field of science require the creation of a new Federal instrumentality. We therefore recommend that a National Research Foundation be created for the promotion of scientific research and of the applications of research to enhance the security and welfare of the Nation." These were words dear to the hearts of the Bird Dogs and the staff of ORI—except that, in their opinion should be assigned to an Office that served naval research. Those sentiments were at the forefront of Navy thinking at ORI. The flurry of interest over the appearance of the report from Dr. Bush started ideas churning, once again, for Bruce Old, Ralph Krause, John Burwell, James Wakelin and Captain Conrad. Navy was the agency best organized to conduct post-war research and neither the Army nor its incipient Air Force sibling were making moves in the direction of forming a proper research oganization. The Navy was prepared to respond, for instance, to the implications of a letter by Dr. Bush to President Truman,

30. Summary begins on page 68 of the report. Subtitle, "A National Research Foundation" begins on page 69.

dated 15 August 1945, in which Bush talks about winding down the operations of OSRD and the NDRC. Bush says in the opening of the letter, "The cessation of hostilities will bring numerous problems in the solution of which the scientists of the country must play an important part. During the war, the scientific effort of the country has been focused on winning the war. That same effort can now properly be focused on the problems of reconversion and education. Industry and the universities need scientific manpower acutely for the tasks which lie before them." On the third page he says, "Even if there were a serious gap in Government supported research as a result of the program outlined herein, however, it would still be wise to close down OSRD promptly." There is already an implication that no agency will be prepared to step into the process of funding and managing research. That kind of talk promoted the advocates at ORI of a strong, central naval research organization to talk about a Congressional Bill that would give naval research a step up—even be able to close the gap between wartime research activities and a successful start-up of peacetime industry and its related research. They worked to produce a draft Bill that could be acted upon by Congress to establish an Office of Naval Research. The second draft of the Bill 'somehow' got into the hands of Congressman Vinson, a long-time friend of Navy and he began to extol its merits on the Hill.

When the Office of Research and Inventions came into being, a plan for enlisting the support and interest of the universities across the land began to take shape. It was decided that the best way to do that was to "sell" the idea of Navy-sponsored research through actual visits to the univerities to talk with the administrators and budget people, letting them know that Navy was willing to pay for good research products. After the war with Japan was finished, the pace began to pick up in stating the case for basic research to serve the Navy. Armed Forces personnel were leaving in larger numbers to go back to civilian life, including scientists. During the latter part of 1945 and on into 1946, Captain Conrad began to travel to the Universities to speak to the administrators, the legal and contract people and the teaching staff about a new concept for funding research that would be less restrictive and less demanding of time and reporting from a scientist conducting investigations in projects of their choice. Conrad became the spokesman for the Navy in efforts to develop a radically different contract system which became the post-war model for attracting scientists into accepting contracts with military organizations to conduct basic research.[31]

Among the documents in ONR Archives is a mimeograph copy of a contract form entitled, "Research and Development Project Order Contract" which has typed in the upper right-hand corner of the facing page the legend, "Navy Department, Office of Research and Inventions, Contract Numbers _____." (The Contract form is a totally blank contract so there are no names or terms included.) Under Section 1—Scope of Contract, a paragraph of text reveals the liberal terms of this new form of contract with the government: "The Contractor agrees to supply all necessary personnel, facilities, and materials, and shall use its best efforts to conduct, within the limits of the Continenal United States, the work specified in Project Order One hereunder, and the work specified in such additional Project Orders as may from time to time hereafter be agreed upon by the Government and the contractor for performance hereunder." Here was an open contract to be made between some University or other agency and the Navy that could be expanded from the base agreement to whatever number of projects the two parties might agree to sustain. It talks of government-provided facilities and equipments as required by the contractor. In Section 9—REPORT OF WORK AND INSPECTION, The text says:

"(a.) The Contractor shall from time to time as requested, submit to the Technical Officer, progress reports in triplicate making full disclosure of all work done under the applicable Project Order, and the results of such work, provided that the Contractor shall not be required to submit reports more frequently than once each month during the term of the contract. Authorized representatives of the Navy Department shall at all reasonable times have the right to inspect the work being performed under this contract."

The example studied by this author is an 11 page document and it illustrates Captain Conrad's message to the University staffs: that conducting basic research under contract to the U.S. Navy would be a personally rewarding relationship, without sacrifice of principles or personal objectives. The contract was almost permissive compared to the experience of most scientists in contractual relationships with government. Of course, the most recent experience, and therefore still clearly etched in memory, was the highly restrictive research and development activities of the war in which classification of information and urgency of requirement were at all times present. The result of that was to create a feeling of regimentation beyond all acceptable behavior of the scientist guided by developing facts and time scales tuned to naturally occuring events. Robert Conrad took it upon himself to define the meaning of the term "Research" in a speech[32] he delivered to the Industrial Research Institute, at the Edgewater Beach Hotel, in Chicago, on 28 February 1947.

31. The same system pertains today in the efforts of the Office of Naval Research to make available the very best talents and skills for Navy research requirements.

32. Copy from ONR files held by ONR Historian along with 12 additional speeches given by Captain Conrad during his attempts to win over the Universities to conducting research under contract to the Navy.

His comments include the following statement: "First, however, it is necessary to define our terms. Research has acquired such qualifying adjectives as "basic," "fundamental" and "applied." Other terms, including "science," "engineering," "technology," "development" and "design" have a variety of usage which invites confusion. The two I shall use most are:

Research, meaning the *search* for new knowledge of nature, and *Development*, meaning the *application* of knowledge.

In accordance with these definitions, research is not objective, whereas development aims at specific results. Research predominates in universities, while development is the main business of an industrial laboratory. Each is closely associated with the other, and they can seldom be entirely separated except in principle.

It is now generally appreciated that our wartime scientific activity consisted of developing the pre-war stock of knowledge accumulated by research into the weapons and devices which the war demanded. Very little research was done during the war; there simply was no time for it. Toward the end, it began to appear that all we could hope for was the continued modification and improvement of the things we already had. The stream of genuinely new ideas had pretty well dried up."

The preceding comments were made by Captain Conrad in 1947 in a formal speech but the ideas expressed were also the core of conversations that he conducted with university officals and scientists to win their interest in the new opportunities for research being offered by the U.S. Navy.

As the winter waned and Spring of 1946 appeared, renewed action appeared in the halls of Congress and in the Office of Research and Inventions. The abiding concern of Rear Admiral Bowen, of Captain Conrad, the Bird Dogs and every disciple of a strong naval research organization was that it come by authorization of Congress. The Office of Research and Inventions was established by an order of the Secretary of the Navy. The planners at ORI were committed to establishing stronger authority as well as a naval research budget dedicated to basic research and not subject to Bureau programming for development requirements. They wanted an Office that was in fact a separate entity, having a clear-cut mission of basic research and authorized to direct naval research rather than coordinate it.

There was a push on for what had become known as the "Vinson Bill" and at the end of July, Congressman Vinson was able to get the Bill through Congress while members were still debating the Vannevar Bush concept of a National Science Foundation. On 3 August 1946, President Harry Truman signed[33] Public Law 588, an enactment of the United States Congress, and brought to life the embryo so long in gestation, the Office of Naval Research. It is, of course, anti-climactic to say it in language so mundane—so benign as to nearly fade from perception. It deserved some kind of cannon salute from the White House lawn. We can be sure that the Bird Dogs, Captain Conrad, and Vice Admiral Bowen and a few other dedicated participants in the creation of ONR would have gladly helped to load the muzzle and pull the lanyard. However, that is infrequently the nature of legislative events. They take their place, unobtrusively, with myriad other actions of the Congress and are observed without fanfare. Such was the relatively quiet launching of the Office of Naval Research.

Authorization by Congress was no guarantee that this new idea would work. That monumental responsibility was assumed by another group of patriots who embraced the concept embodied in this brand new agency for funding basic research—ONR. Included among them were Roger Revelle, Emanuel Piore, Mina Rees, Randal Robertson, Alan Waterman, Tom Killian, Admirals Lee and Solberg, to mention a few of the luminaries who made it work. It was their excellent perception of the Navy's needs and the needs of the universities which doubtless forged their determination and inspired their immensely successful campaigns to attract university science investigators to Navy contracts. They joined Captain Conrad's campaign, so nobly conducted until his untimely death from Leukemia, and carried the struggle to its ultimate success, the realization of leadership in the development of science and technology across the nation and around the globe.

Window Six

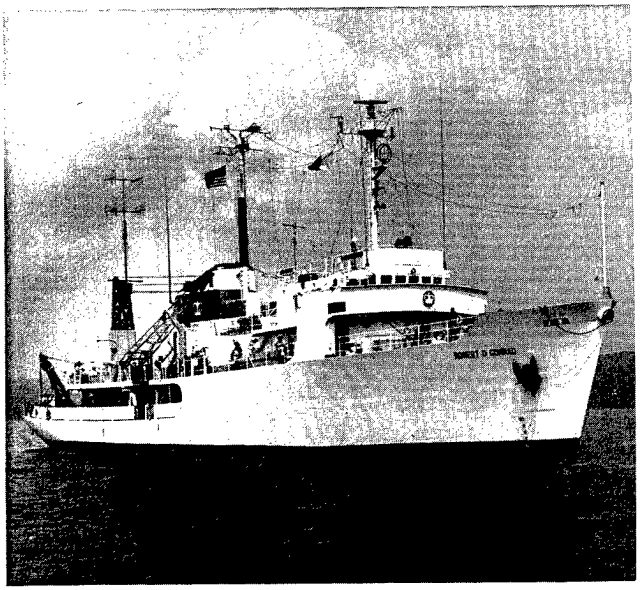
The Vision Out to Tomorrow

Many dedicated patriots labored over the creation of the Office of Naval Research. Now it was necessary to get about the business of peace and on to the reconversion of an incredible war machine back into an industrial resource for satisfying the needs of a nation hungry for private peace and comfort. Freedom had been secured and science was promising release from extremes of hunger, disease, isolation, poverty and ignorance. There were so many things left undone at the end of the war—promising projects that needed strong guidance and continued funding to bring them to term. The Secretary of the Navy had at his disposal $40 million of unspent weapons development money that was moved into the checkbook of the Office of Naval Research. What a difference that made! That was the recognizably effective priming of the pump, but the

33. There is widespread use of 1 August 1946 as the date on which President Truman signed Public Law 588. However, in the Minutes of the first meeting of the Naval Research Advisory Committee, dated 14 October 1946, Vice-Admiral Bowen states: "On the 3rd of August of this year the President signed Public Law 588."

abiding difference which helped the Office of Naval Research quickly get up a head of full steam was the amazing convergence of scientific and administrative skills that assembled at ONR during the first months of its existence.

As the first Chief of Naval Research, Vice Admiral Bowen enjoyed the first months of summitry, at the new pinnacle of naval research activities after a difficult struggle to gain control. Soon after this victory, he announced his retirement to what was described as obligations to a family industry in New England. He was succeeded by Rear Admiral Paul Lee. The Bird Dogs, except Lieutenant James Wakelin, went quickly on to other careers. Eventually James Wakelin left and returned to be appointed the first Assistant Secretary of the Navy for Research, thereby realizing the final aspect of the charter so long recommended by the Bird Dogs.[34] Captain Conrad left in illness and died soon after his departure. He is honored by the most distinguished Navy award in science which is given to extremely gifted persons who have given unusual scientific achievements to the world. A very fine Navy oceanographic research ship bears the name, ROBERT D. CONRAD, and has provided excellent service to the Navy in studies of the ocean environment.



Research Vessel CONRAD

The people who took their places left an imprimateur of their own which set the style and policy for ONR that has become legend. Some of them remain in communication with ONR and continue to share the wisdom of their experience. In an Oral History Interview[35] with Dr. Emanuel Piore, he spoke with eloquence about the very fine spirit of cooperation that permitted ONR to get on with things. He said: "At the end of the war I was still a Naval Officer and I moved into the Office of Naval Research. . .it was about the time that Congress created the Office of Naval Research. . . . ." He went on to say: "I switched to being a civilian and I became head of the research group. Eventually I became Chief Scientist and Deputy Chief of Naval Research. Everything was informal in those days. . . .we actually went to the Bureau of Budget to get money. . . .we actually testified before Congressional Committee on budgets."

Dr. Emmanuel Piore

Piore's conversation reflected the deeply seated sense of mission which comes from the words of so many people who helped to get ONR underway. There is an undercurrent of excitement in the voice and in the choice of words explaining the early activities of ONR; for example, as Dr. Piore commented:

"Oh sure, we felt we had a specific mission and we were missionaries basically to provide the transition from war to peace. That's how we acted. . .we acted with a great deal of what I would call arrogance but not being truly arrogant about it. . .confidence is the word. No one ever told us to stop doing it, once we started and they saw what we were doing and we had the approval of the Naval Research Advisory Committee. . . . . ."
"The Office of Naval Research represented the Navy, the Army. . .nothing formal yet. . .and the Air force had a group at Cambridge. We met annually and gave them a budget and we would go up three or four times a year to review it. That included Stanford, Harvard, Columbia and M.I.T. We were trying to make sure that the brightest could go back to research. Our judgement was reinforced by how well they performed during the war

34. In the article, "The Evolution of the Office of Naval Research," by the Bird Dogs, published in "Physics Today," August 1961, the authors comment: "Perhaps it was a case of poetic justice, but, at any rate, the rest of the 'bird dogs' are happy and proud to report that the very first man appointed to the office of Assistant Secretary of the Navy for Research was one of us."

35. The conversation with Dr. Emmanuel Piore is retained in the Oral History Tape Library at the Office of Naval Research.

in designing equipment. . .no peer review or anything like that because everything was so small that with one or two phone calls you could get the judgement of the community on the quality of the people you were supporting."

Among the many interesting insights he shared concerning the events which shaped the policies and decisions at the Office of Naval Research was the way in which contract money was provided to worthy investigators and projects.

". . . .In order to build the Stanford linear accelerator we put a lot of money into high power Klystron development. . .the tube that drove the linear accelerator. . .we gave it to Stanford, never mind that it was electronics money instead of physics money. They built the first one about 150 feet long and then proceeded to one 500 feet long."

Dr. Piore went on to say, "When we started building the 500 million volt accelerators it was the real beginning of the work in this country that I would call particle accelerators. These smaller machines are now called machines for Nuclear Physics. The thrust for Astro Physics is to use very sensitive instruments to look for objects in space. The feeling was that our assistance in the development of instrumentation would be useful without knowing precisely the application. Then there was a whole business of computers and that has a little different history." He went on to talk about requirements for computer capabilities in Navy intelligence work, for logistics problems and other naval science problems.

His conversation was rich with anecdotes describing the stream of activities that came out of ONR's strong encouragement of research across the nation that would provide basic science needed to advance technology and bolster our industry and commerce.

Dr. Mina Rees provided another stimulating recitation of anecdotes about the sense of mission and the excitement of opening new opportunities for scientific research, particularly in her own special area of mathematics. She was invited by the Navy to come to Washington and join the staff of this new Office of Naval Research. It was Lieutenant James Wakelin who made the trip to extend the invitation for the Navy and to ask her opinion about the possible attitudes of mathematicians toward the Navy's program to fund basic research. She said:

"I had doubts about it because mathematicians are different from other scientists who use laboratories and equipment. . . The mathematician, at that time, sat in an office and did what had to be done. . . why should the military establishment fund peacetime research in mathematics some would say."

Mina Rees had been a key figure in the mathematics programs of war planning in the National Defense Research Committee. Throughout the war she worked closely with wartime administrators of science associated with Dr. Bush and she got to know the status of mathematics across the country. Her grasp of information about mathematicians. . . who were the ones that counted provided for a beginning ONR a prize of great worth. Dr. Rees began at ONR working with Emmanuel Piore who was the Head of the Electronics Branch; Roger Revelle, Head of Geophysics Branch; and Randall Robertson, Head of Materials Branch. She makes the interesting observation that mathematics was a kind of step-child of science as the war came to a close. . . a science not so much identified with research as disciplines like Physics, Chemistry, Biology and others – and then it was changed dramatically by the advent of many European scientists who came to the United States during the war and after spreading across the land to various universities and bringing with them a tradition of research that soon began to enhance U.S. mathematics. The Office of Naval Research began, at the urgings of Dr. Rees, to fund advanced research in mathematics, a turn of events which subsequently put the United States in the leadership role of mathematics research and which provided a solid foundation for numerous technology developments and advances in many sciences. Dr. Rees became the leader of the mathematics program at ONR and continued for years to contribute her invaluable administrative and scientific skills to the programs of ONR.

We need to applaud the vision of Jerome Hunsaker and his perceptive Bird Dogs on another concept. The Naval Research Advisory Committee was intended, right from the outset, to play a special role. The members selected are recognized as distinguished men of achievement. The first meeting of the NRAC was held on 14 October 1946 at the Main Navy Building on Consititution Avenue where important Navy Department actions were still being conducted. The list of attendees included such names as: Assistant Secretary Kenny, Fleet Admiral Chester Nimitz, Admiral D.C. Ramsey (VCNO), Dr. Alan Waterman, VADM Bowmen (CNR), Dr. Detlev Bronk, Mr. Richard J. Dearborn, RADM Luis DeFlorez, Dr. William McCann, RADM Lewis Strauss, Dr. Warren Weaver, and prospective CNR, RADM Paul Lee. Four members who were not able to be present at this first meeting were Dr. Arthur Compton, Dr. Karl Compton, Dr. Lee DuBridge and Dr. Phillip Morse. With that October meeting of NRAC, the Office of Naval Research was, as envisioned by its creators, truly underway.

In the Minutes[36] of the first meeting of the Naval Research Advisory Committee there can be read a succession of statements which help, enormously, to define the philosophies and operating procedures of initial operations at the Office of Naval Research. There is an

36. The Minutes show that W. John Kenney, Assistant Secretary of the Navy, presided with Vice Admiral Harold G. Bowen, Chief of Naval Research, as Co-Chairman. The Minutes are dated 14 October 1946, Room 3601, Main Navy Department Building.

The first meeting of the Naval Research Advisory Committee in October 1946. Left to right rear row: Dr. William Sharp McCann, Director of the Institute of Medicine at Rochester University, Vice Admiral Harold G. Bowen, USN, Chief of Naval Research, Dr. Warren Weaver, Director of the Division of Natural Sciences of the Rockefeller Foundation, New York City, Rear Admiral Lewis L. Strauss, USNR, New York City, inactive duty, Fleet Admiral Chester W. Nimitz, Chief of Naval Operations. Left to right front row: Dr. Detlov W. Bronk, head of the National Research Council of the National Academy of Sciences, Washington, D.C., Commodore Paul F. Lee, USN, who became the second Chief of Naval Research, Mr. Richard J. Dearborn of the Texaco Development Corporation, New York City, Rear Admiral Luis deFlorez, USNR, New York City, inactive duty, and Assistant Secretary of the Navy W. John Kenney.

opening statement by Vice Admiral Bowen which crisply summarizes the formation of ONR in the following words:

"All of you who are here today are probably familiar with the history of the Office of Naval Research, its accomplishments, and its goals. The forerunner of this Office, the Office of Research and Inventions, was established by letter of the Secretary on the 19th of May 1945. It was formed by combining three already active offices and the nucleus of a fourth. The Naval Research Laboratory has been in existence since 1921 and formerly operated under the jurisdiction of the Bureau of Ships. The Special Devices Division was formerly an active part of the Bureau of Aeronautics.The Navy Patent Office operated separately as a function of the Secretary's office. The nucleus of the old Coordinator of Research and Development office formed the beginning of what is now the Planning Division."

Vice Admiral Bowen went on to say, "On the 3rd of August of this year the President signed Public Law 588. This law has three distinct purposes: first, to plan, foster, and encourage scientific research in recognition of its paramount importance as related to the maintenance of future Naval power, and the preservation of National security; second, to provide within the Department of the Navy a single office, which, by contract and otherwise, shall be able to obtain, coordinate, and make available to all bureaus and activities of the Department of the Navy, worldwide scientific information and the necessary services for conducting specialized and imaginative research; and third, to establish a Naval Research Advisory Committee consisting of persons prominent in the fields of science and research, to consult with and advise the Chief of Naval Research in matters pertaining to research.

"Section 4 of this law authorized the Secretary of the Navy to establish a Naval Research Advisory Committee consisting of not more than 15 persons, one member to be from the field of medicine. The primary purposes of this Committee are to consult with and to advise the Chief of Naval Operations and the Chief of Naval Research on all matters pertaining to research."

Following the statement by Vice Admiral Bowen there was a discussion of how many meetings of the Naval Research Advisory Committee should be scheduled during a year and what should be the wording of a charter to define the mission of NRAC.

Captain Conrad, Head of the Planning Division, was then called upon to tell the Committee about the responsibilities of his Division. It is a window all its own into the initial operations of ONR. He begins his statement:

"This Division has the responsibility of constructing the research programs, deciding upon the investment of funds with civilian scientific groups, maintaining the resultant contractual network, and of coordinating the work with the material programs of the Bureaus. These responsibilities naturally involve the Planning Division in the many matters of policy which interrelate the scientific fraternity of the nation with the Navy, and which also concern other government departments."

Next he recites a litany of facts about the business aspects of the early Planning Division operations:

"You have, among the papers before you in these envelopes, the summaries of the contracts, projects, and current plans. We placed 81 contracts during the fiscal year 1946, comprising 177 separate projects, amounting in all to $9,750,000. At present we have placed 42 contracts with 1947 funds, comprising 69 projects amounting to $3,363,000. We have $7,210,000 worth of business in various stages of negotiation, comprising 58 contracts with 152 projects."

A few paragraphs later Captain Conrad says: "Barring economic disasters and wars, we ought to be able to carry this program along for about $25,000,000 a year. This, of course, refers only to the Planning Division side of the work, the investment of funds with civilian agencies for fundamental research". . . ."By next June—June 1947—we should have approximately $30,000,000 worth of work in about 500 projects. A very rough idea of what this means is obtained by simple division which gives $60,000 per project. If you assume that the

average scientist with his overhead and his assistants account for $20,000 a year, that is only three scientists per job, and with 500 jobs that means that we are in touch with about 1500 scientists.". . . ."Nothing like this has ever been attempted before to the best of my knowledge. It began in May 1945 from a handful of people from the staff of the former Office of the Coordinator of Research and Development and has since undergone a series of changes incident to growth and due to the constantly enlarging scope of its responsibilities."

Dr. Alan Waterman, the first Chief Scientist of the Office of Naval Research, expressing his thoughts on the Fundamental Research Program of his responsibility says to the Committee:

"In the first place, I believe you will agree that the establishment of this office has brought about two rather significant steps. The first is the explicit recognition of the importance of fundamental research as applied to national security, and the second is the realization that there's an advantage in some degree of separation between fundamental research and development with its associated research."

Dr. Alan Waterman

Dr. Waterman went on to say, further along in his remarks:

". . . .Now, if one knows the priorities of Navy development work, then one knows what scientific fields are associated and bound up with those developments. With a representative and competent staff in the Planning division of scientists, it is immediately possible to know where in the country one can get the best brains for solving these problems. That is purely a matter of knowing the scientific personnel of the country. That, then, is the clue of where to go.

"Now, as was brought out in responses to a question by Dr. Weaver, it has developed that people have come to us. It wasn't started that way perhaps. We went to the outstanding men in whose specialities we were interested and asked them what they were up to. I would like to point out that the technique is not to go to them and say, 'The Navy has this list of projects which it would like to do. Is there one of those you could do or would be willing to do?'—If you want to enlist the support of the most able investigator—he's the authority, not you—you go to him and say as we have done,. . . ."What do you consider the most important work in your field of research to be done at the present time?". . . .and follow that with,. . ."What would you yourself do if you had suitable facilities and personnel?" Dr. Waterman continues: "That I think, is the way to get really the best work done. He is then free to choose and he is the specialist, not we. If his suggested proposal then comes in line with the things which we know are important and would like to encourage, he is encouraged to submit a proposal which is sent through his department and through the administration of his university so that it is properly cleared with the authorities at the institution."

The Minutes of the first NRAC meeting in October of 1946 present a highly informative description of the initial operations of the Office of Naval Research, as the ONR Division Heads continue with their reports to the Committee. The Minutes also reveal a wealth of genuine enthusiasm expressed by influential and dedicated citizens who rallied to the call for assistance in strengthening the Navy's research programs through this new agency—the Office of Naval Research. Today, we have the advantage of knowing the history of the contribution from the Naval Research Advisory Committee since the day those first meeting Minutes were recorded. NRAC has served the Navy well with valuable assistance to the Navy's research program. Members of the Committee, through passing years, have given unselfishly of their time and talents to bring an extra dimension of professional skill to the process of decision-making about the shape and character of specific naval research goals.

The host of pioneers who put the Office of Naval Research on its feet include names and events that must await the publication of a more comprehensive history than this abbreviated window to the origins of ONR. It is a commonplace in our time to say, or to hear people say, that the Office of Naval Research is largely respon-

sible for providing the impetus and the way for our nation to become the world leader in the development of science and technology following World War II. We recognize that event as the base; the foundation for the growth of our nation's post-war economy, our industrial capacities, and our international political and military strength. As the complete history of ONR is developed, there will be further revelations of the innovative and conscionable manner in which naval research policies were shaped by individuals and events of passing time.

In a Navy Day address at the University of Illinois, Urbana, Captain Conrad expressed the unique mission of the Office of Naval Research, on 27 October 1946. Excerpted from the speech, the following comments embrace the philosophy of ONR that has made it unique in our history, from the onset:

"Curiosity is inherent in the nature of man. Scientific research is one of the highest manifestations of intellectual curiosity. Through research, science merges with philosophy as one of the great works of the human spirit. The urge to conduct research cannot be denied. All research is beneficial. No quest for truth can be otherwise. Its results may be put to use for good or evil, but to stifle research would be to stifle the main hope of humanity." A few paragraphs later he continues:

"From what I have said, it should be clear that it is a contradiction to speak of directing and controlling research. An unexplored country cannot be mapped. It is proper and necessary to plan development work, but research must follow only its inner promptings. Direction by an external authority defeats its own object, for neither the path nor the goal of research work can be forseen." Quoting further:

". . . .The Government must therefore lend public assistance if the national interest is to be served, but this assistance must not degenerate into domination.

"It is in accordance with this philosophy that the activities of the Office of Naval Research are conducted. The responsibilities of the Navy for the national security justify the expenditure of naval funds for research, since otherwise new developments will wither on the vine. It is the responsibility of all of us to be vigilant that Government aid to research shall be in the true spirit of science. . . ."

Those ideas were brought to the campus across the nation by Captain Conrad, the Bird Dogs, and by the dedicated pioneers of ONR who used all of their powers of persuasion and the bonds of professional camaraderie forged in the heat of winning a war to enhance the image of ONR and attract to its burgeoning capacity for funding, the giants of scientific research.

It is time to honor the Office of Naval Research. . .its achievements. . .its dedicated personnel of 40 years. . .and its progenitors who gave it life and purpose. They were convinced the Navy and the Nation needed to have a strong and active research program, to insure that naval development moves forward at the cutting edge of advancing science and technology. In this 40th year of the Office of Naval Research, it is appropriate that we have an opportunity to review the past and to draw upon a rich history of accomplishments to enhance our own aspirations for the future and to give to those who labored in the task of making ONR succeed, a Hearty Thanks!

Acknowledgments

I would like to acknowledge the generous assistance and the patience of many persons who have helped me identify sources of information required to prepare the following monograph about the origins of the Office of Naval Research (ONR). I have had the unforgettable pleasure of interviewing a number of people who played decisive roles in the actions which established ONR and helped to shape its mission and policies. Dr. Bruce Old has been a constant and gracious guide through early war time documents and their significance. He provided much of the written information I have studied. I want to also thank Mr. Ralph Krause, Dr. Randal Robertson, Dr. Mina Rees, Dr. Emmanuel Piore, Dr. Cornelius Roosevelt, and Dr. James Wakelin for sharing their memories about the beginnings of ONR.

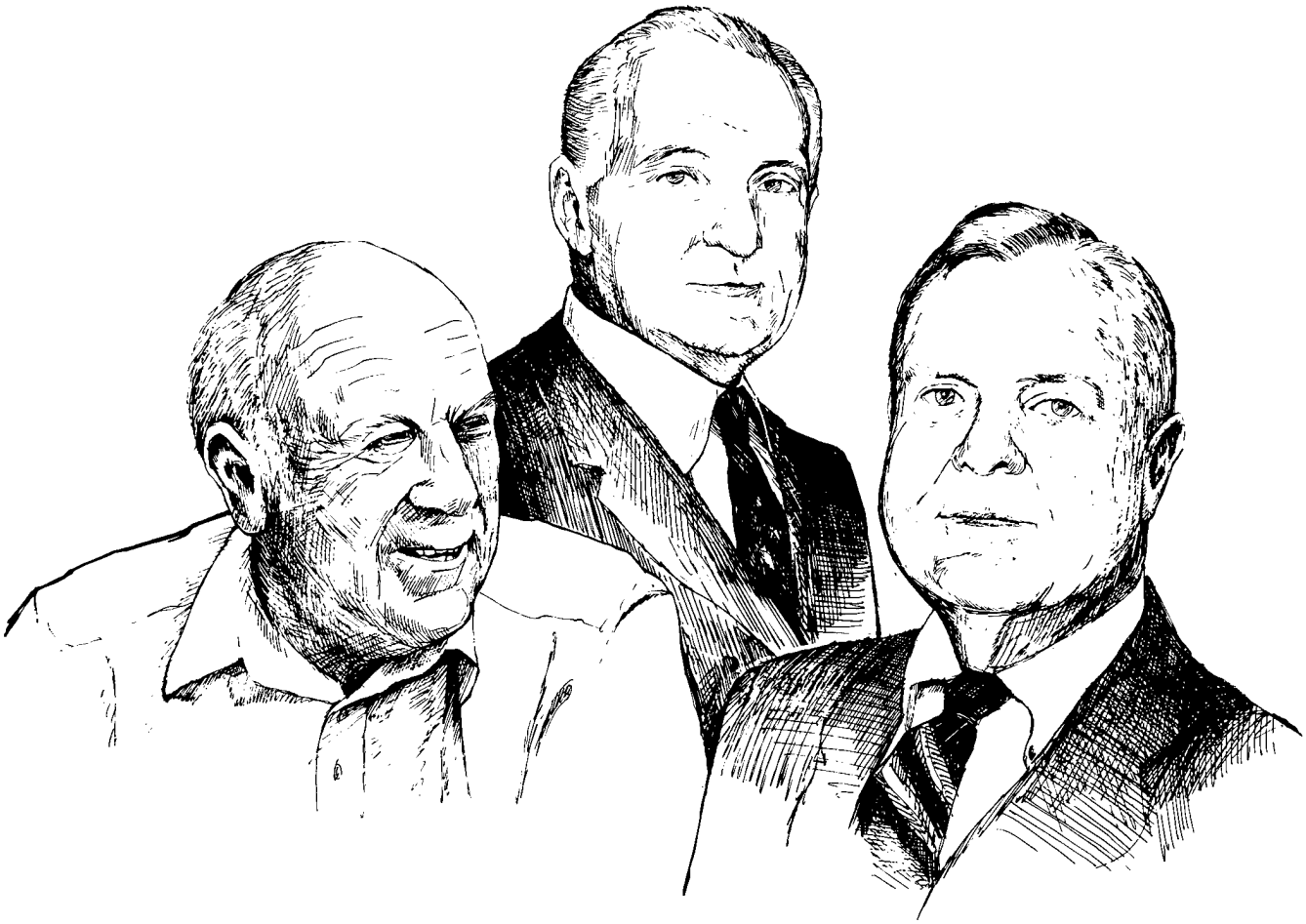
I have had the privilege of interviewing many other pioneers who have provided invaluable information about the early years at ONR. Those interviews will richly enhance research for the comprehensive history of ONR that will be written later. My great thanks, also, go out to Miss Eunice Mohri who has been with the Office of Naval Research since 1947. Her sense of history about ONR is impressive and has played a significant role in judgments about sources and interpretation of information in the writing of this monograph.

Finally, I want to thank the two persons who made this project possible and chose to include me in its conception. First, my thanks to Dr. Marvin K. Moss, Director of the Office of Naval Research, and to Rear Admiral J.B. Mooney, Jr., the Chief of Naval Research, who proposed that the ONR history be captured, and offered me the opportunity to do this. With admonitions to have the history ready for the 40th Anniversary of ONR I requested permission to prepare a monograph that would explore the origins of ONR and, simultaneously, accommodate work on the comprehensive history to appear at a later date. My thanks to Dr. Moss and to Admiral Mooney for this challenge of high interest and my thanks to many, many people on the staff of ONR who have helped me prepare this introduction to the history of the Office of Naval Research.

R. D. Hagen

Profiles in Science

Dr. James H. Wakelin, Dr. Bruce S. Old, and Dr. Ralph A. Krause were among the group of six nicknamed the "bird dogs" because they were directed to "ferret out" the capabilities of navy laboratories prior to the U.S. entering World War II. After the war the "bird dogs" were instrumental in laying the groundwork and preparing the legislation for Public Law 588, which established the Office of Naval Research (ONR) in 1946. These men were naval reserve officers who were called to active duty and worked for the Navy's Coordinator of Research and Development and later joined the Office of Research and Inventions, which was the predecessor of ONR.



Ralph A. Krause, James H. Wakelin, and Bruce S. Old (left to right), three men important in the founding of the Office of Naval Research 40 years ago.

James H. Wakelin

In 1959, President Eisenhower appointed Dr. Wakelin the first Assistant Secretary of the Navy for Research and Development; he held this position through the administrations of Eisenhower, Kennedy, and Johnson. Previously, he served the Navy on active duty in the Office of the Coordinator of Research and Development and then as Head, Mathematics, Chemistry, and Materials Division for the Office of Research and Inventions which became the principal component of the Office of Naval Research in 1946. After World War II, he served as director of the field survey group of ONR's magnetic sensor project called SQUID (Super Conducting Quantum Interference Devices) under contract to Princeton.

While he was Assistant Secretary of the Navy, he represented the Defense Department as a member of the Interagency Committee on Oceanography and was its chairman from 1960 through 1964. Included among the technical and administrative positions in industry and government, he was Chairman of the President's Task Force on Oceanography and Assistant Secretary of Commerce for Science and Technology. He also served as Vice Chairman of the Naval Research Advisory Committee (NRAC), which was created by Public Law 588 to advise the Chief of Naval Research.

Dr. Wakelin's published papers are primarily on the physical structure and properties of natural synthetic rubber and textile materials. Also he is coauthor with C. B. Tompkins and W. S. Stiffler, Jr., of *High Speed Computing Devices*, one of the earlier publications to describe in detail the mechanics and electronic devices in the growing field of machine computation (McGraw-Hill Book Co., 1950).

Bruce S. Old

Dr. Old is a retired Senior Vice President of Arthur D. Little, Inc. Currently he is President of Bruce S. Old Associates, Inc., a consulting firm in Concord, Massachusetts. He has been responsible for several novel developments in iron and steel manufacture, employment of radioactive tracers, and engineering applications of atomic energy.

During World War II, he was on active duty in a liaison capacity between the Office of Scientific Research and Development, National Advisory Committee for Aeronautics, the Army and the Navy on a variety of research matters. He participated in the first Alsos Mission (nuclear weapons intelligence), was a member of the War Metallurgy Committee and helped draft the bill establishing the Office of Naval Research.

Dr. Old has undertaken a number of projects on research management including studies for numerous industrial laboratories, basic research in the Navy, research strategy in the Department of Defense and criteria for project selection for the National Aeronautics and Space Administration (NASA). He has served on many committees of the National Research Council and was a member of President Eisenhower's Science Advisory Committee.

Ralph A. Krause

Mr. Krause was the first Director of Research of Stanford Research Institute, Menlo Park, California in 1948 and is today an Associate Director. His publications and research have been in the fields of electronics, electrocephalographic equipment design, radio circuit design, magnetostrictive pressure gauges, radar, nuclear instrumentation, and research administration.

During World War II, he coordinated for the Navy research efforts in electronics and radar and set up research facilities. He helped formulate policies and programs for establishing ONR and became the Head of the Scientific Division of ONR's San Francisco Branch.

From 1963 to 1967 he was Principal Director, Department of Applied Science of the United Nation's Educational and Scientific and Cultural Organization (UNESCO) and administered the UN's special fund projects on technical education and research. The governments of Mexico, Bulgaria, and Romania invited him to organize technical research and training facilities for their countries. He has been a consultant on international science and technology for the U.S. State Department, studying food and agriculture in Indonesia and participating on factfinding missions in Latin America.

FORTY YEARS ON THE FOREFRONT OF SCIENCE

The origins of the Office of Naval Research (ONR) date back to the final months of World War II with the impending disestablishment of the Office of Scientific Research and Development (OSRD). OSRD was a civilian agency established during the war for the purpose of obtaining the services of the most capable scientists and engineers throughout the nation to do research on weapons and warfare problems. It was a wartime agency destined to be abolished after the war; the civilian scientists and engineers would then return to their pursuits in the universities or industry. The great scientific momentum built by OSRD would be lost.

Near the end of the war, a group of naval officers, with the support of eminent scientists, succeeded in persuading the Navy to respond to the problem and prevent the loss of the scientific resources which produced the technological achievements of the war. These technological advances were made possible by drawing on a base of fundamental research performed years or decades before the war; the Navy objective was a permanent naval research organization which would supervise Navy-wide research programs and support civilian science, solidifying the partnership between the scientific and military communities developed by OSRD. By supporting on a long-term basis top civilian scientists at universities and in industry, the Navy would be provided with a constant flow of new knowledge. The Navy then would not have to depend on mobilization of scientists in time of war when it would already be too late to obtain immediate technological advances.

A bill for the establishment of the present Office of Naval Research was drafted and submitted to Congress. It was greatly aided by the impact of the publication of "Science, the Endless Frontier," a report by the head of OSRD, which proposed a centralized federal research agency. The bill was passed and became Public Law 588 on August 1, 1946, formally establishing the Office of Naval Research with the mission to "plan, foster, and encourage scientific research in recognition of its paramount importance as related to the maintenance of future naval power and the preservation of national security."

The Navy found itself the sole government agency with the power to move into the void created by the phasing out of the OSRD, and ONR became the first federal agency with the statutory authority to support basic research. While the civilian-run OSRD was concerned primarily with applied, war-related classified research, ONR was to be concerned primarily with basic, unclassified academic research. It became a model for other federal agencies that were to be established later, such as the National Science Foundation (NSF), and the National Institute of Health (NIH). In fact, ONR's first Chief Scientist later became the first director of NSF. Both the Army and the Air Force followed the Navy's pattern in the establishment of their research offices. ONR moved quickly and aggressively to establish a contract research program through which science could be funded solely or partially by the Navy and performed by scientists at universities, non-profit organizations and industrial laboratories as well as Navy laboratories.

Investigations ranged over just about the entire area of science that was new and important—nuclear research, low temperature physics, solid state physics, radio astronomy, basic biological studies, computer and information sciences. ONR was responsible for the construction and operation of the first large radio telescopes, such as the one in the Owens Valley, 260 miles from Los Angeles and operated by California Institute of Technology. ONR's work in solid state and quantum physics in the 1950's was instrumental to the modern age of electronics.

The world leadership of the United States in basic research in the two decades following World War II has been attributed in great part to the timely and imaginative work of the Office of Naval Research and its support of eminent scientists. About half of all Nobel Laureates in the physical sciences at one time or other worked on projects funded by ONR.

Through the funding of researchers and graduate students who assisted the principal researchers, ONR contributed greatly to the training of a new generation of scientists and engineers.

There is virtually no piece of equipment or system in the modern Navy whose development does not include ONR research. Defense technologies conceived and carried forward through ONR research include the maser and the laser, the electronically suspended gyroscope, modern electronic navigation systems. ONR conducted the first man-in-the-Sea efforts which established the physiological limits to man's ability to live and work in the ocean's depth. The first true deep-diving submersible, ALVIN, was constructed with ONR funding. ALVIN opened most of the ocean bottom to manned exploration and provided a critical tool for search and recovery. Modern sonar for long range detection of submarines, for probing the ocean and for ocean bottom geophysics resulted in large measure from ONR work. Under ONR support, Dr. James A. Van Allen discovered the radiation belts in space which bear his name. ONR was the first to support studies in low temperature physics, a field of studies which was the monopoly of European science before the war. Applications from these investigations include superconducting motors for ships and cryogenic applications for aeronautics and space systems.

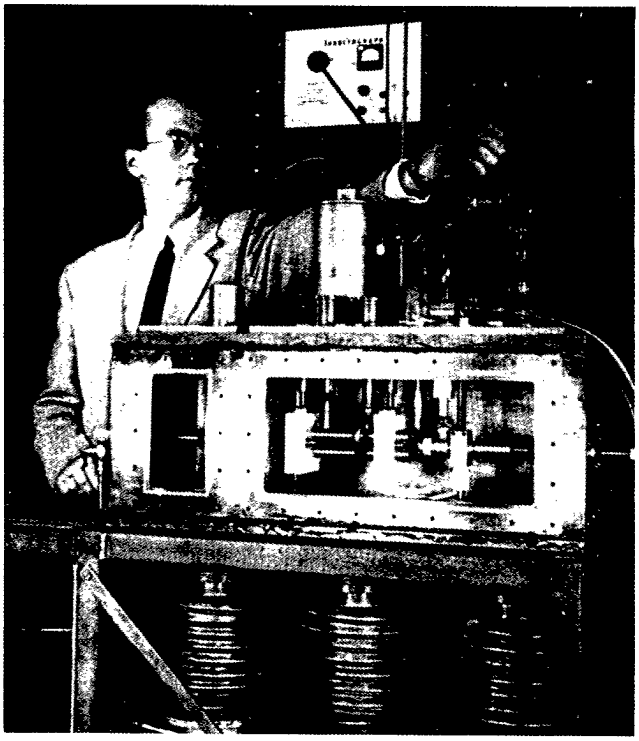
Appropriately, a great number of ONR research efforts have to do with the environment in which the Navy operates. Most of the modern instrumentation which is used to measure and unravel the kaleidoscope of interacting forces at work in the ocean environment were developed as a result of research sponsored by ONR.

Remote sensing of the environment, now a vital component of the arsenal of tools needed to monitor the environment to the benefit of such activities as fisheries, agriculture, weather prediction as well as defense-related mission, got a boost through ONR. The very term "Remote Sensing" originated in the Geography Branch of ONR in 1961 when a research project entitled "Interpretation of Aerial Photography" was renamed "Remote Sensing of the Environment." The new term was coined to reflect development of remote sensors capable of making observations beyond the range of human vision and photographic sensitivity.

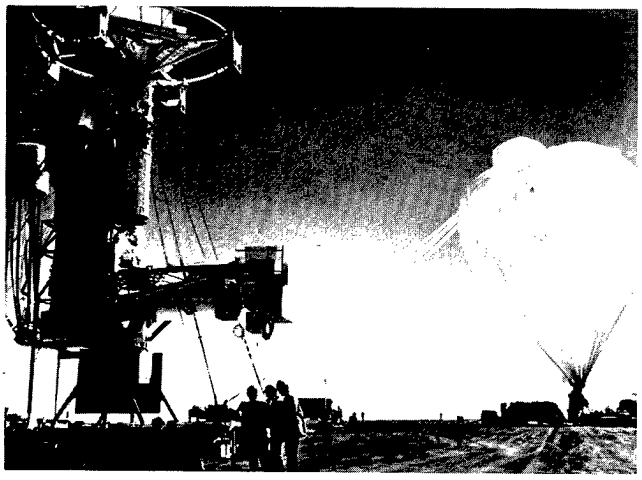
Navy-oriented projects funded by ONR have produced results which can, and have had application in the civilian community. Some of these include: biomedical research aimed at producing a universal blood type which can be utilized in blood transfusions regardless of the type of the recipient; methods of clearing fog from airports, resulting from investigations in atmospheric science funded by ONR; a long-term research effort in fluid lubrication and gas bearings produced the gyroscopes now used in inertial navigation systems. These same gas bearings are common now in high speed tape transport and in flying heads for computer disk memory. Other civilian spin-offs of Navy research include new metals and alloys; stronger, lighter and corrosion proof composite materials; paints and lubricants; long lasting and compact batteries; and a host of other products and techniques used in the home, industry and service institutions.

Most of ONR's research is performed under contract by scientists at universities, industrial laboratories as well as in Navy laboratories, especially ONR's Naval Research Laboratory in Washington, D.C. ONR also administers three other laboratories—the Naval Ocean Research and Development Activity and the Institute for Naval Oceanography, both in Bay St. Louis, Mississippi, and the Naval Biosciences Laboratory, Oakland, California. ONR maintains three field detachments in Boston, Chicago, and Pasadena. In addition, there is a Branch Office in London and a Scientific Liaison Group in Tokyo to provide a point of contact and report on significant scientific developments in Europe and the Far East. As a part of its mission to conduct and coordinate research, ONR establishes Navy policy on matters involving patents, inventions, trademarks, copyrights, and royalty payments, and matters connected therewith.

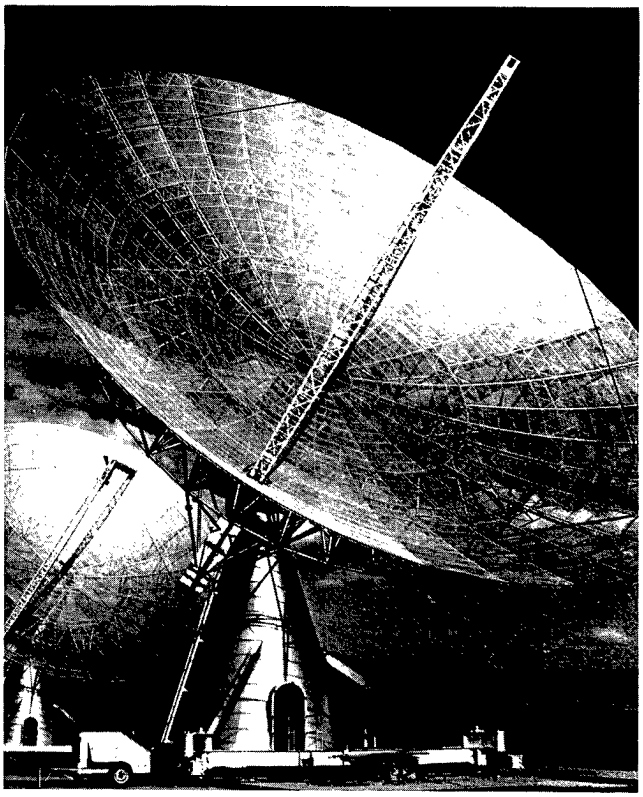
Although several changes have taken place in ONR since its establishment, its goal remains unchanged: to plan and conduct the research needed for the development of tomorrow's technology for the Nation and the U.S. Navy.



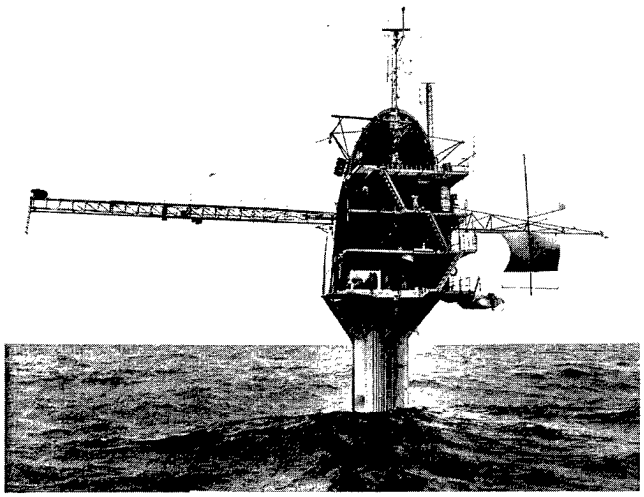
Professor Charles H. Townes is shown with the ammonia beam maser he developed in the early 1950's at Columbia University. This was the first molecular oscillator and amplifier and led to the development of the general field now called quantum electronics. This research was funded by the Office of Naval Research, the Army, and the Air Force.



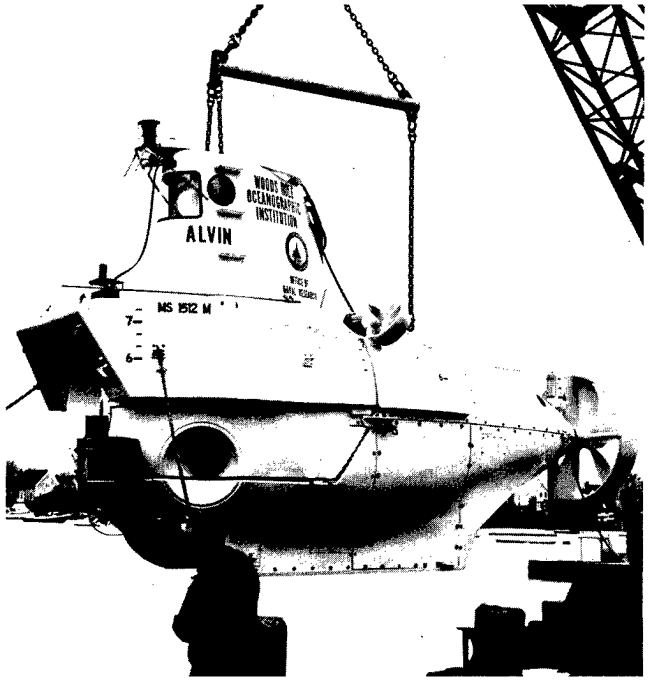
The Stratoscope II telescope is shown in launch position in 1963 during inflation of its carrier balloon. The launch balloon is filled with 305,000 cubic feet of helium. The telescope, lofted to an altitude of 80,000 feet, operated above 98 percent of the air and water "blanket" that surrounds the earth, and data can be obtained free of the absorptive effects of the atmosphere. The 6,300 lb., balloon-borne telescope collected new and vital data on Jupiter and the giant, red stars. The telescope was launched as part of the Office of Naval Research's Stratoscope II program.



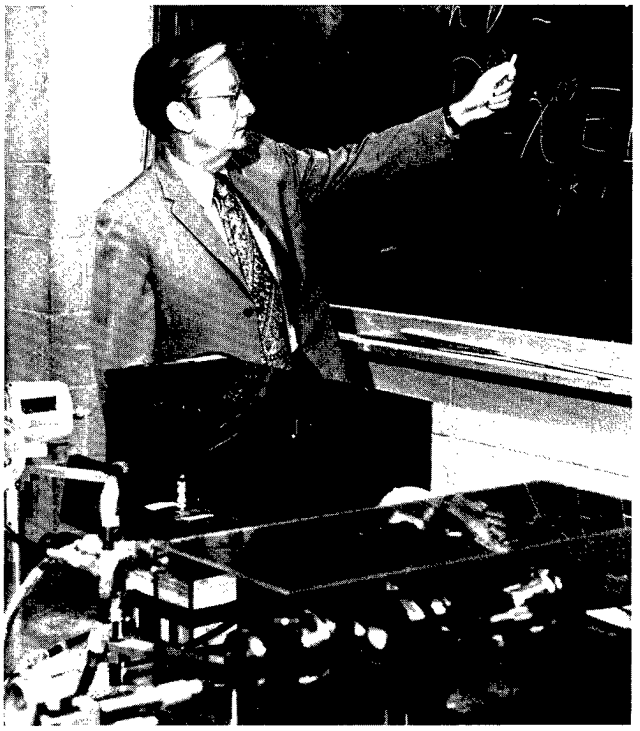
Giant twin radio telescope, located in the Owens Valley, 260 miles from Los Angeles, was built in 1959 by the California Institute of Technology with funds from ONR. During the first two months of operation, the telescope located and identified nine new radio sources outside our galaxy. Working in tandem, the 90-foot dishes produced a resolving power greater than any radio telescope of the day; that is the ability to pinpoint radiating objects in space. During the formative years of radio astronomy, ONR was the major sponsor in the United States. The Owens Valley telescope was one of several built and operated with ONR funds during the 1950's through the 1960's.



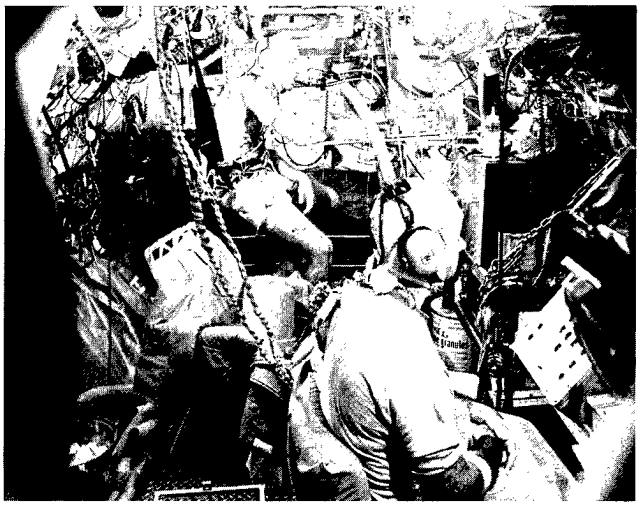
FLIP is an unusual vessel developed in 1962 under the sponsorship of the Office of Naval Research at Scripps Institution of Oceanography. This 355-foot floating instrument platform known as FLIP can be towed behind a ship in a horizontal position to its destination. Then, its ballast tanks are flooded, it tilts to an upright position, and all but 55 of its 355-foot length disappears below water, providing an extremely stable platform. It is used for research into such areas as wave attenuation; sound propagation, scattering, and reverberation; seismic wave recording; and measurement of internal waves.



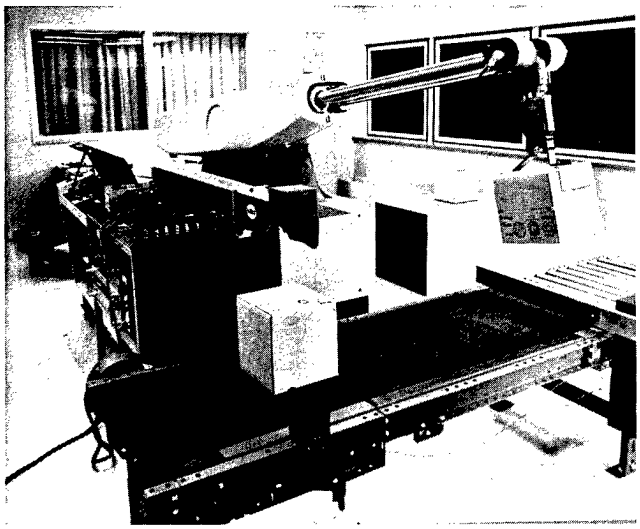
The three-person submersible ALVIN is a national research vehicle supported by the National Science Foundation (NSF), the Office of Naval Research (ONR), and the National Oceanic and Atmospheric Administration (NOAA). ALVIN's depth capability today is 4,000 meters (13,134 feet). The nation's first research submersible was built by ONR in 1964 when this picture was taken.



This 1974 photograph shows Professor Nicholaas Bloembergen beside his Nd-Yag picosecond pulse laser apparatus in his Harvard University Laboratory. Professor Bloembergen uses this apparatus in nonlinear optical experiments, which he has been conducting for 35 years with the support of the Office of Naval Research. His pioneering research in the interaction of high intensity laser beams with matter launched the discipline of nonlinear optics.



Subject-divers Gerard B. McHale (background) and Frank H. Sayle in active 1973 experiment-excursion between 1200 and 1600-foot depth. Sayle is engaged in mental, visual and auditory function measurements and McHale in respiratory-circulatory and neurological studies. This was part of a long-term program at the Institute of Environmental Medicine, University of Pennsylvania supported by ONR.



This programmable industrial robot is carrying a package to a designated position after package code marks have been recognized by a laser scanner device. This program in advanced automation, started around 1970, was initiated at Stanford Research Institute with the help of a survey sponsored by ONR. It has now expanded into a large program sponsored by National Science Foundation and ten industrial affiliates, dealing with inspection, material handling and assembly.

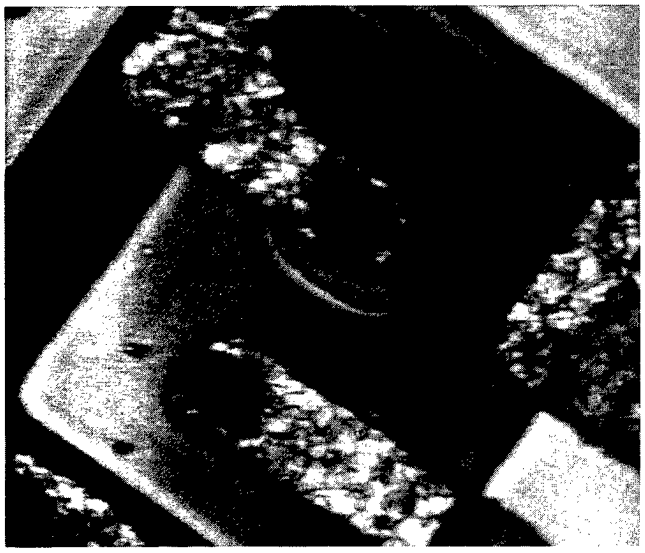
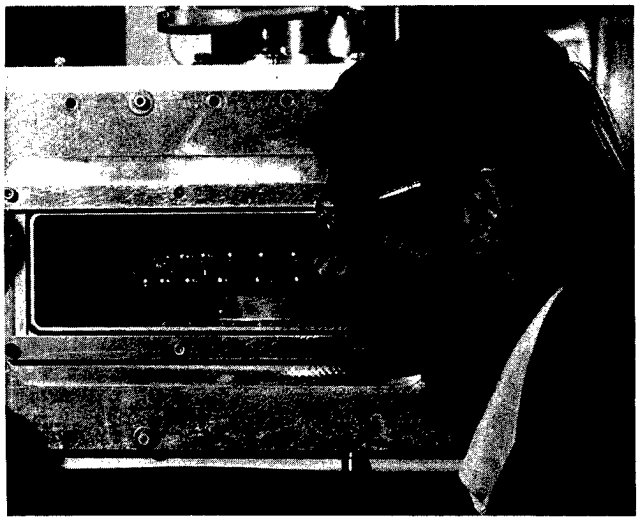
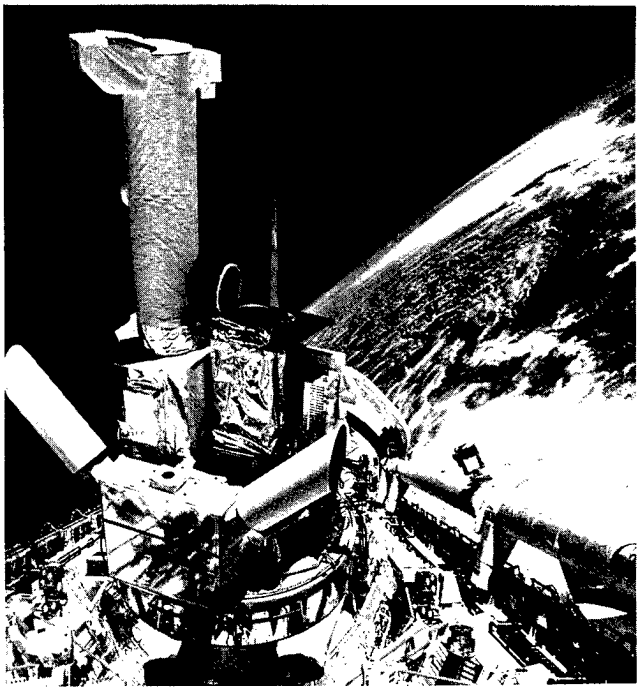


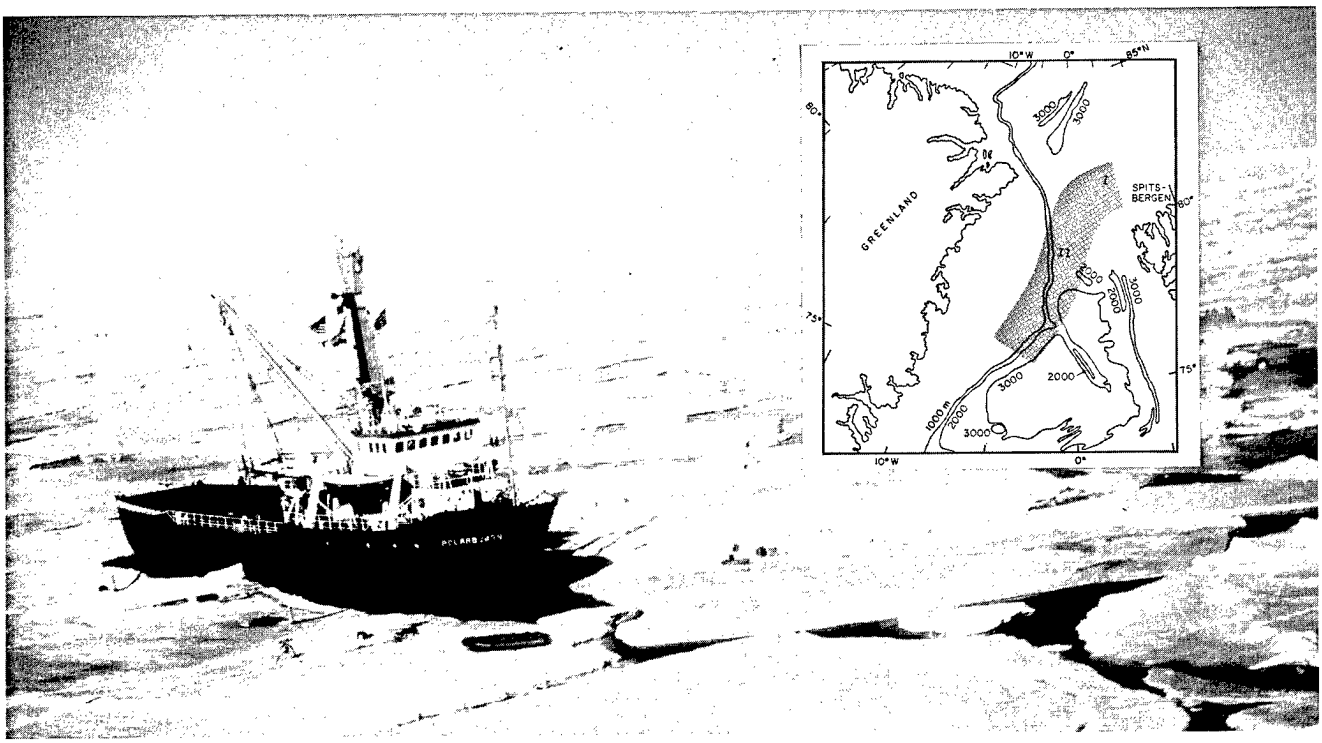
Image of a bipolar transistor obtained with a cryogenic scanning acoustic microscope in 1983. The aluminum conductor strips are about two millionths of a meter wide. The microscope can be compared to a very small scanning sonar with a frequency several million times that of sonar. Certain properties of materials or component parts which cannot be seen when using the reflection of light with a conventional microscope, can be observed by the reflection of sound. This acoustic microscope can be used to inspect small details of electronic components such as chips because its resolution is better than an optical microscope. ONR has supported the basic research on this microscope which is now ready for commercial application.



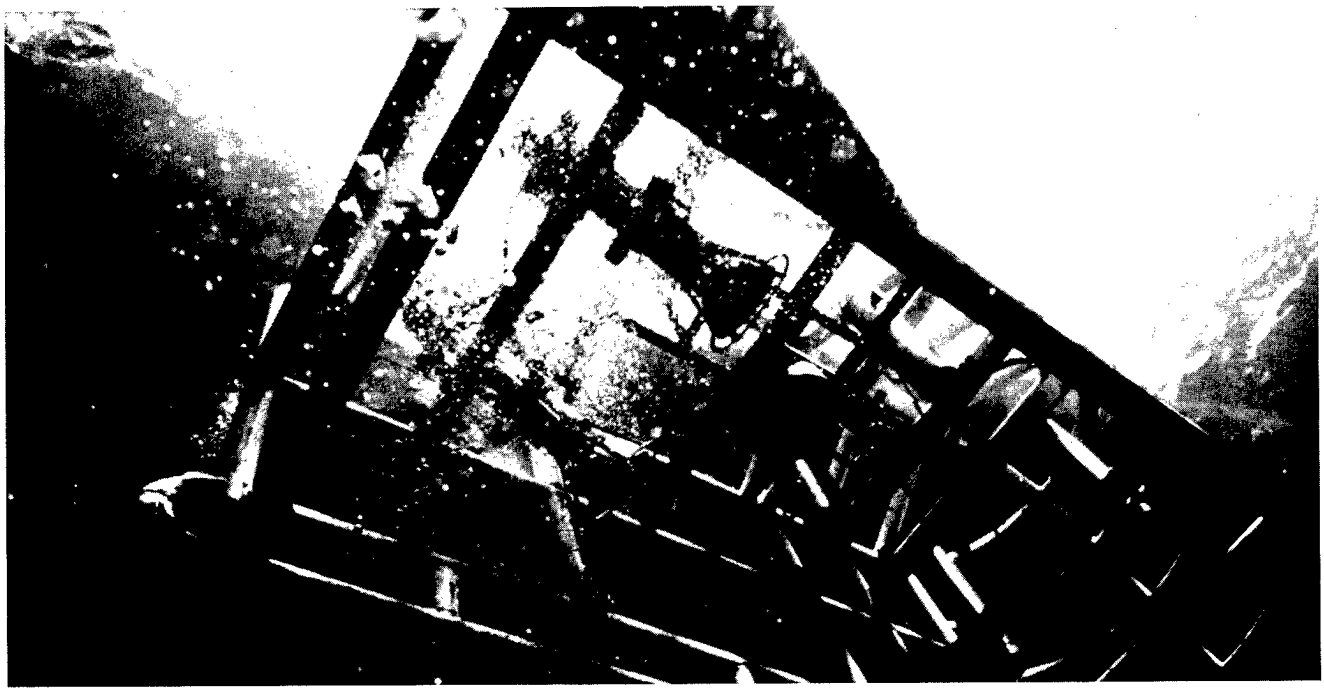
Dr. Graham Hubler of The Naval Research Laboratory examines the rolling elements of a J-79 bearing during ion implantation with chromium ions. The glow is caused by fluorescene of highly excited atoms sputtered from the surface by the 150-keV chromium-ion beam. Ion implantation consists of injecting atoms of any desired element electronically into the surface layer of a metal, producing an intimate alloy without the sharp interface characteristics of a coating. This technique can make wear-resistant parts that increase manyfold the lifetime of the engines or systems in which they are used.



Two Naval Research Laboratory solar experiments were flown on the Space Shuttle's Spacelab 2 on July 29, 1985. Shown here is the high resolution telescope and spectrograph (HRTS) which was designed and built by NRL to measure the ultraviolet radiation from the sun. NRL astrophysicist Dr. John David Bartoe was aboard Space 2 as a payload specialist.



Marginal Ice Zone Experiment (MIZEX) was the most extensive environmental field study ever undertaken of the Arctic region in the summer of 1984. Primarily funded by the Office of Naval Research, MIZEX was designed as a drifting experiment covering approximately 125 square miles of the east Greenland Sea. Scientists from ten nations participated in this study of remote sensing, meteorology, ice, oceanography, biology, modeling, and acoustic.

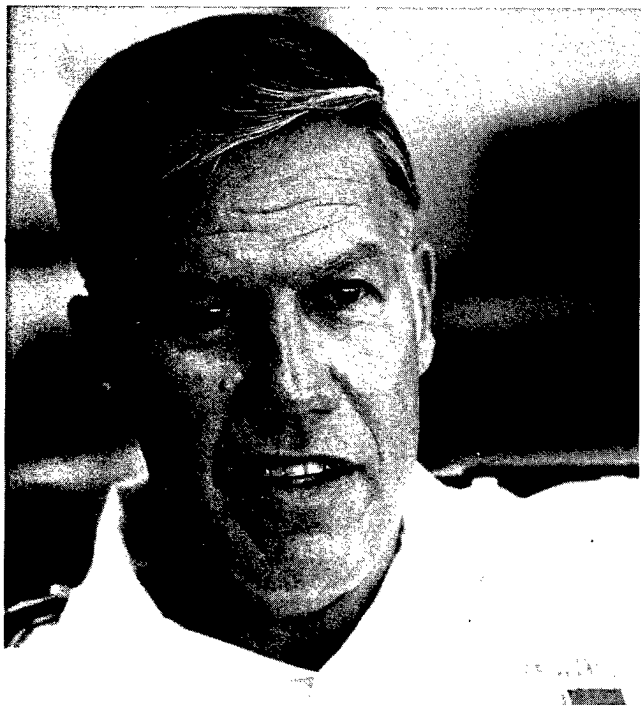


ANGUS (Acoustically Navigated Geological Underwater Survey) was used with the ARGO video camera system to survey the TITANIC in 1985. It was the first search and survey system developed by the Woods Hole Oceanographic Institution with ONR funding. It can work in depths to 20,000 feet and is equipped with up to three 35 mm color cameras each having 400 feet of film.

ONR PERSPECTIVE: INTERVIEWS

To launch this 40th anniversary year of the Office of Naval Research, Rear Admiral J. B. Mooney, Jr., USN, Chief of Naval Research, and Dr. Marvin K. Moss, Director of the Office of Naval Research, discuss the relationship ONR shares with the science community and talk about ONR accomplishments over the past four decades. They also identify management challenges and scientific opportunities faced by the Navy's basic research and development community as it endeavors to meet the needs of the Navy in the future. The questions were prepared by the editors of *Naval Research Reviews* (NRR).

RADM Mooney Questions and Answers



NRR: Historically, the National Science Foundation was patterned after the Office of Naval Research and many of NSF's early leaders, including the first NSF Director, Alan Waterman, came from ONR. Yet today, the two agencies differ in many respects. How can these different evolutionary patterns be accounted for?

RADM MOONEY: Actually, the two agencies have much more in common. Both have benefited over the years from the pioneering efforts of ONR's early management in setting the tone for the government/university Research and Development (R&D) relationship. Furthermore, both agencies stress scientific quality in their program selection. However, there has been a difference in the evolution of programs and procedures in the two agencies that reflect significant differences in mission.

ONR has a mission to support the highest quality research in areas of potential naval interest and to transfer the results of that research and the research of others to appropriate Navy users. Although the majority of ONR's program is performed at universities, approximately 35% is performed at Navy laboratories. Because of its mission orientation, ONR must place greater emphasis for project selection on its scientific officers who must be knowledgeable in both their scientific discipline and in relevant naval requirements. As such, the scientific officers—SOs—play a key role in project selection and management. They are given broad discretion in the selection of external projects for support, and are then held responsible for their results.

The SOs seek the advice of associates within the Navy and of appropriate experts external to the Navy. The methods employed to seek expert advice, which may be highly structured or informal, are determined by the SO to meet the particular needs of his or her program.

NSF has a general mission to support research in virtually all areas of science to broadly advance the national knowledge base without specific response to specific ultimate uses. Since virtually all of the NSF program is performed at universities, peer review of proposals at NSF is a formal process.

NRR: What is the relationship with ONR and the Navy's overall R&D structure?

RADM MOONEY: By today's corporate standards, ONR is not a large organization; and it represents a relatively small segment of the total Navy Research, Development, Test and Evaluation activity. Even though it is often viewed as being embedded in this larger effort which includes the Navy Systems Commands and R&D Centers, ONR is an independent organization reporting directly to the Secretary of the Navy.

We view the combination of basic research and the developmental efforts at organizations such as the Naval Research Laboratory in Washington, D.C., the Naval Environmental Prediction Research Facility in Monterey, California, and the Naval Ocean Research and Development Activity (NORDA) in Bay St. Louis, Mississippi, as valuable Navy assets. Such a combination adds the reality of application to the basic research program while ensuring that exploratory development efforts take full advantage of the very latest and most advanced scientific knowledge.

Another factor in the ONR investment decision process is the ability to leverage available internal resources. Selective investment by ONR often attracts additional research dollars from within the Department of Defense (DOD), as well as from other government agencies. ONR tries to play a role in getting research started in critical fields without having to carry the total support burden. The multitude of joint and/or co-managed programs with the Defense Advanced Research Project Agency (DARPA), Strategic Defense Initiative Office (SDIO), the Air Force, the Army, other parts of the Navy, as well as with other government agencies is testimony of the importance of this factor in ONR management.

NRR: What balance is there between passive and active roles in choosing research to be funded?

RADM MOONEY: There is no passive role in ONR's approach in the sense we only sit and wait for proposals. Program execution is carried out in an environment of active two way communications with the scientific community concerning both research options and naval research objectives. We actively pursue the development of research goals and objectives through a planning and budgeting system that attempts to balance competing roles.

As such, we work with the scientific community in exchanging information on objectives and scientific research approaches, and our program managers work with a wide range of peers and naval users in deciding program content. Workshops and advisory groups are utilized in developing program thrusts. ONR scientific officers and managers are continually visiting universities and Navy laboratories and other research organizations to communicate our priorities to actively seek out new research opportunities.

NRR: How has ONR been able to support a significant amount of basic science while contributing materially to the Navy's mission-derived needs?

RADM MOONEY: First of all there is very high scientific content in Navy systems, and so it is very natural that there is a close tie with basic research. Military systems tend to push the frontiers of technical possibility and hence provide a strong impetus for the acquisition of new scientific information. Of course, ONR is guided by its mission, as defined under Public Law 588 which established ONR in 1946. Both the Secretary of the Navy and Department of Defense management have provided a policy context supportive of ONR's role in the sponsorship of basic research relevant to the Navy mission.

From this framework stems the integration of military and civilian scientific managers who serve to blend basic research opportunities and knowledge with the needs of the Navy. Consequently, we are engaged in a continuing effort to communicate naval needs and scientific opportunities through systematic planning, workshops and related programs. The ONR scientific officer is responsible for seeking out new developments in science and nurturing their maturation and transfer to development and application.

One of our objectives is to maintain a dialogue between the Navy and science communities. For example, workshops are held where Navy problems are presented to university and industrial scientists, and we keep in close contact with the Fleet—the user of our research accomplishments. This contact leads to efficient application as well as identifying needs for future research.

NRR: What ONR programs or functions particularly strengthen ties between Government labs, industry, and academia?

RADM MOONEY: In a broad sense they are the full spectrum programs under ONR involving science and early technology development. The real strength, however, stems from the concept of every ONR program manager being responsible and accountable for working across institutional boundaries in order to promote greater program coherence.

The initiation of special programs with the objective of strengthening ties in selected areas of naval mission interest is an important factor with respect to blending academic, industrial and naval lab tasks. For example, virtually all of the programs included in our recently established University Research Initiative Program involve strong incentives for the establishment of substantive university/Navy laboratory interaction, including selection criteria and the availability of matching funds.

NRR: Who are the major performers in Naval Research?

RADM MOONEY: U.S. universities account for 56% of the basic research funds budgeted by ONR. These university researchers are funded primarily by the Contract Research Program which administers $222 million of FY86's $365 million budget. The four ONR Laboratories, and the eight Navy R&D Centers (Navy Laboratories) account for an additional 35% of the ONR research budget. Finally about 9% of the program supports work performed at industrial and non-profit laboratories.

NRR: What new programs or policies initiated by you will change ONR's management of science?

RADM MOONEY: Block research programs supported under the University Research Initiative (URI) program will provide funds to universities to perform multidisciplinary

science and engineering research and to educate students in disciplines that underline a strong modern Navy and national defense. Such programs will be funded for five years at several million dollars. Each program will plan for the exchange of information and scientists between Navy laboratories, R&D Centers, and universities.

Another is ONR's Young Investigators Program, which is intended to attract the best young academic researchers on a tenure track at U.S. universities to areas of research that are important to the Navy's future requirements. Each year about 10 to 12 awards of $50,000 per year for three years are given to persons who received a Ph.D. on or after January 1980. ONR will match on a 2-for-1 basis any support which the successful applicant gets from other naval sources. Such matching funds are limited to $80,000.

A third contribution, under the direction of the Secretary of the Navy, is the four research chairs in oceanography instituted last year. The recipients are located at the Scripps Institution of Oceanography, Woods Hole Oceanographic Institution, Massachusetts Institute of Technology, and Florida State University. The objective of these chairs is to ensure a strong Navy ocean science program by attracting the best academic scientists and students to work on oceanography. Each chair carries an allocation of $200,000 per year for three years.

In addition, the Secretary of the Navy directed ONR to create the Institute for Naval Oceanography located at Bay St. Louis, Mississippi, but independent of NORDA. It will be operational in October 1987 for conducting ocean modeling efforts for R&D programs leading to better and in many cases new capabilities for ocean forecasting. This work has the potential for significantly improving support for naval warfare missions and weapon systems development.

NRR: What are some areas of research where ONR has been a dominant force for the past two or three decades?

RADM MOONEY: As you can imagine, the list is quite extensive, but in general, over the years ONR has been a major supporter of certain areas of science whose every facet seems to pertain to the Fleet and its operation. In these areas, which include, among other disciplines, oceanography, metallurgy, and laser development and application, not only does ONR support new research, but ONR scientists must keep current at all times with the latest developments.

In oceanography, ONR has been a pioneering force in developing the discipline itself from rather humble beginnings to its effective role today. ONR strengthened the oceanographic community through support of Woods Hole and Scripps as well as other universities and the research fleet. Significant research contributions have been achieved in physical oceanography on nearly all scales from basin-wide circulation to microstructure. ONR studies here enhanced our understanding of major currents, fronts and eddies, and have led to the Garrett-Munk spectrum, which describes the energy distribution of the internal waves in the ocean. Recent accomplishments in remote sensing and numerical modeling are impressive. In other oceanographic areas, ONR has developed deep-tow and other mapping sensors to better understand solid-earth issues including plate tectonics and bottom acoustics. Beach processes, marine adhesives, acoustic fluctuations, chemical variability, and vortex foils for dredging are important contributions in related oceanographic areas.

In metallurgy, ONR has kept on the forefront developing new and improved metals such as titanium and molybdenum that have filled critical needs in advanced aircraft, missiles, and nuclear reactors. Coming out of a 15-year research program on the plastic behavior of metals are the origins and foundations for all of today's theories in this area. Kinetic hardening, limit theorems for plastic work, and normality requirements for plastic deformation laws all come from ONR funding. Also, for many years ONR has been a leading force researching the mechanisms of hydrogen embrittlement, leading to longer-lasting alloys. Other important and ongoing programs pertain to dynamic crack propogation, composite transducer materials, and deformation of superalloys.

ONR has a long history of continued support of basic research on new laser concepts and improved laser sources. The first successful application of stimulated emission was made in 1954 by Charles Townes and his students at Columbia University with partial support from ONR. In 1958, Arthur Schawlow and Townes analyzed the conditions necessary for gain and oscillation in the optical region, and two years later the Hughes Research Laboratory reported the first laser in ruby. The Hughes work was rapidly followed by the discovery of the heliumneon gas laser in 1961 and the P-n junction laser 1962. After lasing was achieved, research was accelerated in fields relating to laser technology: light propagation, absorption and scattering, glass and other materials, flash guns, and molecular physics. New laser concepts and the construction of new lasers including gas lasers, tunable lasers and lasers in new parts of the spectrum were developed. Laser applications cover such diverse areas as laser surgery, holography, fiber optic communications, laser gyros, welding and materials processing, isotope separation, optical data storage for computers as well as audio and video disk players, laser fusion, and directed energy weapons. Recent accomplishments from ONR-supported research have been the low voltage free electron laser and laser cooling and trapping of neutral atoms.

NRR: What do you think could accellerate progress in naval research?

RADM MOONEY: First on the list, of course, would be more money. However, a continuing objective is better coordination and cooperation between industry, universities, and Navy laboratories. ONR could expand its promotion of this cooperation through several broad and interdisciplinary programs coordinating various research facilities on the same project.

Also, ONR is and has been supporting programs to encourage students to pursue higher education in engineering and science, because maintaining a cadre of well-trained young scientists is vital to the future of naval science and to the future of our Nation. ONR supports this philosophy through four such programs:

The *ONR Fellowship Program* awards each year 40 three-year fellowhips to outstanding graduates to persue work for a doctorial degree in areas of science and engineering critical to the Navy.

The *University Research Instrumentation Program* provides funds for university research equipment in the $50,000 to $500,000 range to support areas of research interest to the Navy.

The *Navy Science Awards Program* allows ONR to sponsor high school science fairs to encourage students to continue their educations leading to careers in science.

The *Apprenticeship Program* provides a platform from which ONR investigators can hire high school students during the summer to assist on research projects. Here again, the purpose is to encourage careers in science and engineering.

NRR: How has the role of ONR changed within the Navy and within the scientific community during the past years?

RADM MOONEY: The basic mission and need for ONR has not changed over the years—to obtain the best scientific research possible for the taxpayer and to make the most effective use of this research for the Navy. However, research priorities do change with time. Every year new techniques and new discoveries open new avenues for research thrusts.

ONR's current policy is to use flexible contract procedures in carrying out the largest basic research program in the Department of Defense, with projected funding at $365 million in FY86. ONR's Contract Research Program, is our primary support program for U.S. scientists at universities and other research organizations outside of the Navy. The ONR program provides the Navy with creative ideas and information in the physical, mathematical, environmental, engineering, and life sciences needed to optimize future naval operations. The ONR program has two components: Core Programs and Accelerated Research Initiatives, with resources split about evenly.

The Core Program consists of contracts in the traditional scientific disciplines. Heavy weight is given both to scientific merit and technical approach, with particular emphasis on "new" science. The Core offers the possibility of examining new and burgeoning high risk science areas and maintains a level of effort in scientific areas which are broadly relevant to other areas of science, technology and to Navy needs.

The *Accelerated Research Initiatives* are designed to concentrate resources in specific areas of research which offer a particularly attractive scientific opportunity. These Initiatives are neither more applied nor more basic than the Core Programs. They represent an accelerated or enhanced program in basic scientific areas which are potentially attractive to future naval needs. Some of the typical areas now being pursued include: Stable and Chaotic Behavior in Physical Systems via Non-Linear Dynamics; Environmental Remote Sensing with Synthetic Aperture Radar; and Biotechnical Application of Microbial Processes from Archaebacteria.

NRR: Can you give some examples of how basic research conducted by ONR support has led to improvements in naval operations?

RADM MOONEY: ONR has shared in the development and testing of much that you see onboard a ship today such as: the radar, the surveillance systems, the missiles and weapons systems, the combat control center, the materials for ships hulls, training devices, and communication systems. The thousands of ONR innovations that have been implemented in the Fleet range from the fracture-safe high yield strength steel alloys, currently employed in submarine hulls, to the low-noise microwave amplifiers used in the radar systems on F-14 fighter aircraft. ONR does the exploratory research necessary to see that certain new ideas, materials, and devices are possible as well as useful for the Fleet, while advanced stages are performed by Navy laboratories, other government agencies, and private industry.

Let me sum up by saying that we are currently engaged in several important ongoing programs worthy of note, which include new oceanographic instruments and long-range buoys for collecting and transmitting oceanographic data, and a worldwide navigation system. We continue to fund research for improving long-term storage of whole blood and developing a universal blood type. We are still pioneering work in lasers and their applications and developing super-sensitive ship sonars. Our global research efforts include perfecting Arctic under-ice operations. Important also in our programs are atomic magnetometers; high energy, long-lasting batteries; and, in materials, new alloys of high strength steels, paints, lubricants, and composite materials. We have an assured leadership role in research on electronic devices with the potential for higher frequencies and much faster computing speeds than anything available today. ONR encourages the acquisition of fundamental knowledge needed to solve future military problems in areas such as communications, surveillance, targeting, propulsion, mobility, guidance and control, navigation, energy conversion, materials and structures, and personnel support. Consequently, the Navy of the 21st Century is being planned now through the research supported by ONR.

Dr. Moss Questions and Answers

NRR: Looking back over the past forty years of ONR, what are your general impressions of this "Grand Experiment" which the Congress and President Truman initiated in August of 1946?

DR. MOSS: One of the fields that felt the early impact of ONR research was nuclear physics. Before the Atomic Energy Commission was formed, the Office of Naval Research played a vital role in enabling the United States to move ahead in this field. Most of the 15 nuclear research accelerators that were built at universities in the decades following World War II were started under ONR sponsorship. And as you know, the Navy has become a big user of nuclear energy.

Research on fundamental atomic properties by ONR lead to the atomic clocks and other extremely accurate clocks now used in the Navy's time service and in such modern navigation satellites as the Defense Global Positioning System. The master clock, which is actually a number of computers linked to provide an average reading of atomic oscillation, is accurate to within one nanosecond. The accuracies are essential to navigation of ships, submarines, aircraft and missiles, but they are also required for worldwide communications.

One of the very early accomplishments of ONR that had measureable impact on the very social and economic structure of our nation was the funding in 1946 of Project Whirlwind at Massachusetts Institute of Technology (M.I.T.). Initiated as an engineering basic research project aimed at developing a high-speed computer for use in an aircraft trainer-simulator, in 1949 it evolved from the development of a high-speed analog computer to the development of a high-speed digital general purpose computer. Directed by Jay Forrester and Robert Everett, Project Whirlwind has had a far broader impact on our society than air defense. Numerous inventions came out of the project including magnetic core memory, which revolutionized the entire computer industry. M.I.T. licensed major computer companies to use magnetic core memories and certain companies to manufacture the cores. Royalties to M.I.T. from sales amounted to about $25 million from 1958 to 1973. Whirlwind personnel formed a number of new companies. Not only were major accomplishments in science and engineering made but this government's investment of about $17 million has reaped over $600 million in taxes from one company alone. Whirlwind also demonstrated early concepts of computer-aided design and manufacturing and computer time sharing—all of which are big business today. People trained during Project Whirlwind have migrated to important positions in teaching, in industry and in government. Over one hundred graduate students were trained. Their efforts are now building second and third generation contributors to our society in increasing numbers. All of these impressive paybacks came from funding of the Whirlwind Project at M.I.T.

Further, the Navy's funding of deep-sea research laid a foundation for much of our nation's ocean industry while simultaneously playing an essential role in the improvement of naval operating capabilities in the undersea environment. ONR sponsored such initiatives as the purchase, in 1958, and use of TRIESTE in the initial explorations of the deepest parts of the world ocean, including the deepest dive ever accomplished. The commissioning of the submersible ALVIN in 1964 provided the Navy and Woods Hole Oceanographic Institution with a new facility for exploring the seafloor and the underwater environment. In 1966, with the present Chief of Naval Research, Rear Admiral J. B. Mooney, Jr. aboard as Executive Officer, ALVIN, in joint operations with various other underwater tools and facilities, made a successful recovery of the "H-Bomb" that had been dropped in the sea off the coast of Palomares, Spain. A pressure hull made of a specially developed titanium alloy, in a project sponsored by ONR, now permits work at depths of 12,000 feet in the sea. From Navy's Deep Sea Technology Program funded by ONR there was developed a "family" of underwater work tools which provided the technology required to begin accomplishing work in the extremely demanding undersea environment of crushing pressure, darkness, cold and unknown terrain. From that technology, ocean industries such as offshore drilling for oil, harvesting fish and seafood, as well as seafloor mining have drawn heavily to develop their own hardware and positioning requirements. The development of special metal alloys sponsored by ONR in the Deep Sea Technology Program played an essential role in the concept and development of advanced aircraft and for the Polaris and Poseidon missiles, as well as our Fleet Ballistic submarines.

These technical achievements were matched by ONR's contributions to the development of the science of oceanography. Through its long-term commitments to the academic and oceanographic institutions, ONR has helped engender a pioneering quest to understand the oceans. Selected recent accomplishments include development of capabilities to collect and transmit *in-situ* data to understand ocean structure, including energetic eddies, internal waves, and air-sea conditions from moorings and underway vessels; the discovery and exploration of hydrothermal vents on the sea floor from manned submersibles and remote optical/acoustical platforms; and the use of satellite remote sensing to monitor ocean waves, temperatures, chlorophyll, and dynamic parameters, as well as the creation of a global navigation capability. Excitement still surrounds the return of Paul Scully-Power from his space flight with unmatched images of the ocean.

ONR has sponsored major contributions in electronics and solid state physics such as: the development of three terminal devices including the gallium arsenide transistor, microwave ferrite devices (radar), the modern theory of superconductivity, digital computing, magnetic recording, quantum and fiber optics, integrated circuits and semiconductor memories, superlattices, and quantum well devices.

Another program studying permafrost soils and geomorphy of the Arctic established the technology that helped in the construction of the Defense Early Warning (DEW) line, as well as the Alaska oil pipeline.

A long-term basic research effort in fluid lubrication and gas bearings produced the gyroscopes used in inertial navigation systems. These same gas bearings are now common in high-speed tape transport and in flying heads for computer disc memories.

NRR: How does ONR interface with the broad research community and the Navy's technical systems offices and the operating forces?

DR. MOSS: ONR's primary mission is to support fundamental or basic research. Most of the research is performed at the universities of this country by outstanding scientists and engineers. ONR will often follow up with limited programs in exploratory development, which means the first stages of implementation or application of basic research. When research has progressed under ONR support to show promise for Fleet application, ONR encourages the Navy Laboratories, Systems Commands, or industry, as appropriate, to support the program for further evaluation and development.

ONR's extensive corporate laboratories (Naval Research Laboratory, Washington, D.C.; Naval Ocean Research and Development Activity, Bay St. Louis, Mississippi; Naval Biological Laboratory, Oakland, California; and Naval Environmental Prediction Research Facility, Monterey, California, and the new Institute of Naval Oceanography at Bay St. Louis) help not only in the selection of problems in the basic research areas, but in the transition of programs, as they mature, to higher Research, Development Technology and Evaluation (RDT&E) categories.

ONR also established field offices and resident representatives around the country and in London and Tokyo very early in its history. These offices encourage the exchange of information and transitions from research to development. Another important area of exchange is from the wide range of naval users of research with whom ONR program managers work in deciding future program content. We spend months developing a detailed compilation of Navy and Marine Corps needs which guide the relevance of many of our programs. Workshops and advisory groups composed of university, laboratory and private sector scientists and engineers are utilized in developing other program thrusts. Research planning for quality and relevance constitute year-round concerns and attention.

NRR: Does ONR get guidance from outside the agency such as from the Chief of Naval Operations as to what research to pursue?

DR. MOSS: ONR receives guidance on the operational strategies and needs of the Navy, as well as their broad technological implications from the Chief of Naval Operations. Guidance on DoD research policy and objectives and in matters of laboratory and university research program objectives and administration is received through ONR's line responsibility to the Secretary of the Navy. The communication of this guidance is established through formal reporting and program review procedures, and is broadened by ONR measures for maintaining Fleet liaison and interfaces at the OPNAV/ASN (Naval Operations/Assistant Secretary of the Navy) level.

Given this broad guidance from higher authority, ONR develops its research objectives and program by integrating Navy needs and their technological implications in its guidance to its own research claimants and through an extensive research option review and award procedure. On a continuing basis, ONR solicits further guidance largely in the course of expert advice from a number of established National Academy of Sciences panels and the panels of the National Academy's Naval Studies Board. In addition, all research activity undergoes formal coordination and receives further guidance in the course of reviews by the Under Secretary of Defense for Research and Engineering, through active ONR participation in interagency and inter-service committees, and through interaction with the scientific community.

NRR: To what extent does ONR rely on in-house laboratory research, and what value to ONR do you place on the availability of these labs?

DR. MOSS: Thirty-five percent of the research program is conducted in-house. For Fiscal Year 1986, the basic research budget is $365 million, and of that about 20 percent goes to ONR Laboratories, 7% to Navy Systems Commands, and 8% to the eight RTD&E Centers of the Director of Navy Laboratories.

The in-house labs are invaluable to the Navy and to the implementation of ONR's programs. They serve as a source of specialized research capability in fields of high naval interest which are not adequately covered in academia or industry, e.g., ship research; explosives; propellants; marine materials; and command, control and communications. They serve as a highly responsive element being intimately familiar with naval needs and, therefore, can effectively extend, specialize and transition general scientific results into naval applications. The Navy labs serve as scientific elements and expert advisors (together with the R&D Centers) to help the Navy be a more aware and sophisticated buyer in major systems oriented programs. And they serve as a source of feedback to academic researchers and ONR program managers on Fleet needs and the analogous research priorities.

NRR: What characteristics helped ONR to achieve such an impact on science . . . that is to say, what characteristics contribute to its efficiency and relevance?

DR. MOSS: Because of its unique mission, ONR depends primarily on its Scientific Officers for the selection of specific research projects. Academic peer reviews cannot be expected to be knowledgeable about the naval mission and its research implications. It is ONR's exceptional cadre of Scientific Officers who made its past record of achievement possible. ONR Scientific Officers are encouraged, as a matter of policy, to be active researchers and to play a leadership role in the scientific community while, at the same time, establishing and maintaining close communication with the Navy technology development and operations communities, who will ultimately use the products of their research programs.

Because of the requirement to select programs that have outstanding scientific merit and fit into an overall set of programmatic priorities, ONR Scientific Officers must play a very active role in communicating ONR's programmatic interests and priorities to the academic community and in seeking out scientific opportunities relevant to the Navy priorities. Not only do they spend considerable time visiting university laboratories and scientists, they also organize special conferences and workshops and monitor and participate in relevant activities of the National Academy of Sciences, professional societies and other organizations.

The scientists and engineers funded by ONR are able to carry out their research programs with a minimum of administrative details and reports. Also the ONR policy of encouraging some efforts in areas of high risk research is attractive to the academic community.

ONR is able to focus research funds to high payoff areas through a system called Accelerated Research Initiatives—ARI's—that are selected on a competitive basis at the corporate level. Research Options proposed by the claimants as candidate ARI's represent programmatic areas of exceptional opportunity where a concentration of funding of limited duration, typically five years, can yield exceptional benefits from the point of view of advancing fundamental understanding or from the point of view of the transition of new ideas into development and application. Although the exact amount varies from year to year, roughly 8% of the ONR research budget is set aside each year to fund new ARI's that are selected in a rather structured competitive process that includes inputs from peer review type expert panels. Because of the five year average lifetime for ARI's, roughly 40% of the total Navy research program is devoted to ARI's at any given time.

NRR: What are the various mechanisms ONR employs for peer review or proposal selection? What is the general method of program selection?

DR. MOSS: ONR has an informal peer review process keyed to competent scientific managers who have demonstrated they can establish rapport and work effectively with the scientific community. Interaction with the scientific community keeps them abreast of what is being done and by whom.

The total ONR research program is divided into 15 technical disciplines which we refer to as subelements. For each of these subelements or disciplines, we provide extensive yearly assessments of past progress, future trends and new opportunities for Navy relevance. We have established a National Academy of Sciences (NAS) Panel for each of our disciplines. The NAS panels provide us with an analysis identifying and discussing the opportunities for priority research areas in a given field, as seen from their outside ONR, science-related perspective. The ONR/NAS reports on priority research topics are updated on a three year cycle.

In any given year, from 20 to 40 Research Options are received from the claimant organizations as candidates for Accelrated Research Options. An ARI is a special program putting large dollar amounts behind a "ripe" scientific research program—an accelerated program that can potentially benefit the Navy in a significant way. A panel of experts is formed to evaluate each group of Research Options. Since the panels are asked to address research quality, transition potential, and Navy relevance for each Research Option, panel members are selected to include experts in these three areas of each option. Typically, the research experts come primarily from the university, but also include government and industrial laboratories; transition experts come from

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the Office of Naval Technology and the Naval Systems Commands; and relevance experts come from the Naval Systems Commands and the Chief of Naval Operations' staff. Last year, 75 scientists and engineers from other organizations participated in the ONR Research Option evaluation process.

The selection of the tasks which make up a broad program begins with the decisions of the scientific managers. In establishing new programs or tasks, care is taken to solicit the views of other researchers in the field, elements of the Navy research laboratory community, and, when appropriate, acquisition personnel associated with Navy development projects. The criteria employed in evaluating specific proposals are based on scientific excellence, Navy relevance, and potential ability for transition to the Fleet.

NRR: What are these ARI's and what role do they play in ONR's investment strategy.

DR. MOSS: Let me give an example. One relatively new ONR initiative which will contribute significantly to science and the future needs of the Navy is known as Ultra-Submicron Electronics Research (USER). This is a comprehensive program of fundamental research on the materials, fabrication processes, and devices for future solid state electronics systems. Future improvements in digital integrated circuits, electro-optic components, and microwave/millimeter wave components will require precise fundamental understanding and control of device features with dimensions as small as a few atomic spacings.

The USER initiative has supported many leading scientific investigations in critically important areas such as ultra-thin semiconductor layer deposition, metal-semiconductor contacts, high-field charge transport, microscopic defects, and quantum mechanical effects. USER-sponsored research will undoubtedly lead to greatly enhanced capability in electronic signal and information processing for a wide range of naval needs, such as surveillance, communications, command and control, and electronic warfare. Many other such examples exist.

NRR: In what major areas of science and technology will ONR concentrate during the next few years?

DR. MOSS: The following are among the areas of major thrusts: mathematical analysis, modeling and simulation; technologies for automations; submicron structures; biotechnology; electrooptic systems and signal analysis; high performance composite materials; computational fluid dynamics; and oceans science and engineering—to name a few important ones.

In the years ahead, ONR will continue to devote a large part of its funds to university research—maintaining the historical and profitable relationships with scientists on university campuses. At the same time ONR will remain flexible enough to plan and conduct, on its own initiative, research and engineering experiments to meet changing naval requirements. ONR will continue to blend the talents of the civilian scientific community with the needs of the Navy for rapid technological advances in order to create the strong, capable new Navy that must evolve during the coming decades.